AIR FORCE

HUMAN RESOURCES

EXPLORATORY MODELS TO LINK JOB
PERFORMANCE TO ENLISTMENT STANDARDS

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December 1988

Final Technical Paper for Period April - December 1987

DTIC
ELECTE
1989

LABORATORY

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5601

89 2 1 035

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	Approved for public release; distribution is unlimited.

4. PERFORMING ORGANIZATION REPORT NUMBER(S) AFHRL-TP-88-39	5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION Advanced Technology, Incorporated	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Training Systems Division

6c. ADDRESS (City, State, and ZIP Code) 4615 Walzem Road, Suite 208 San Antonio, Texas 78218	7b. ADDRESS (City, State, and ZIP Code) Air Force Human Resources Laboratory Brooks Air Force Base, Texas 78235-5601

8a. NAME OF FUNDING / SPONSORING ORGANIZATION Air Force Human Resources Laboratory	8b. OFFICE SYMBOL (If applicable) HQ AFHRL	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F41689-86-D-0052

8c. ADDRESS (City, State, and ZIP Code) Brooks Air Force Base, Texas 78235-5601	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO	WORK UNIT ACCESSION NO
63227F	7734	13	01

11. TITLE (Include Security Classification)
Exploratory Models to Link Job Performance to Enlistment Standards

12. PERSONAL AUTHOR(S)
Gott, C.D.

13a. TYPE OF REPORT Final	13b. TIME COVERED FROM Apr 87 TO Dec 87	14. DATE OF REPORT (Year, Month, Day) December 1988	15. PAGE COUNT 102

16. SUPPLEMENTARY NOTATION

17.	COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	aptitude measurement job performance
05	09		criterion development job performance measurement
05	08		enlistment standards linkage models selection/classification testing

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Joint-Service Job Performance Measurement/Enlistment Standards Project was initiated by Congress in 1980 to develop job performance measures and to subsequently link such measures to enlistment standards for military jobs. The results of these efforts will enable the services to better answer vital questions of military quality requirements. The progress to date has primarily been in the development of job performance measures. The next objective is to relate these on-the-job performance measures to enlistment standards. This paper responds to the second objective by reviewing and evaluating available linking methodologies. Structured interviews were conducted with personnel in key Air Force offices involved in recruiting, selecting, and classifying enlisted personnel to discuss current procedures and candidate models. As a result, four linking models were identified and evaluated: the institutional expectancy chart, break-even analysis, the time to proficiency model, and the Rand cost/performance tradeoff model. Each of these models was analyzed within a common evaluative framework that addressed required inputs, computational requirements, quality of outputs, and strengths and weaknesses of the technique. Evaluation results generally supported the use of the expectancy chart and break-even analysis for simpler linkage goals (e.g., to determine the impact of enlistment standards on general mission capability),

(Continued)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT [X] UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Nancy J. Allin, Chief, STINFO Branch	22b. TELEPHONE (Include Area Code) (512) 536-3877	22c OFFICE SYMBOL AFHRL/SCV

DD Form 1473, JUN 86   Previous editions are obsolete.   SECURITY CLASSIFICATION OF THIS PAGE

Item 19 (Concluded):

> whereas the time to proficiency and Rand models were better suited for more complex goals involving cost-benefit ratios and more precise productivity indicators. Reported conclusions emphasized the importance of (a) the goal-setting process as the first step in pursuing linkage methods, (b) the support from the Air Force selection and classification community to test and implement any model, and (c) the type of job performance measures used (i.e., norm-referenced versus criterion-referenced tests).

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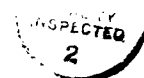
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Reviewed and submitted for publication by

Hendrick W. Ruck, Technical Advisor
Training Systems Division

SUMMARY

The objectives of the Joint-Service Job Performance Measurement/ Enlistment Standards Project are to develop on-the-job performance measures and to relate such measures to the setting of enlistment standards for job entry. The services' progress to date has focused primarily on the first objective. This paper considers available methodologies that can provide the linking mechanism for the second objective. Interviews were conducted with personnel in key Air Force offices involved in recruiting, selecting, and classifying enlisted personnel in order to better understand the current selection and classification process and to discuss candidate methods and procedures. Four linkage models were identified and evaluated: the institutional expectancy chart, break-even analysis, the time to proficiency model, and the Rand cost/performance tradeoff model. Each of these models was analyzed with respect to varied Air Force goals for linking performance to enlistment standards and in terms of required input data, efficiency of computational requirements, and suitability/quality of output. The overall evaluation of the models led to the following general conclusions. The Air Force must initially decide which goal to pursue from among the various possibilities; e. g., to validate the Armed Services Vocational Aptitude Battery (ASVAB) scores as predictors of job performance or, as a more complex goal, to determine what levels of ASVAB predict various levels of job performance at what costs. Different models are suitable for different goals. The ability of available linkage models to achieve Air Force goals depends, in general, on the quality and type of job performance measures used. This paper is intended to aid the decision making process regarding suitable linking methodologies.

PREFACE

In response to Congress, the Department of Defense initiated job performance research and development (R&D) approximately 5 years ago to develop a technology for accurately measuring job performance. The Air Force R&D plan was developed in coordination with the other services to ensure that all programs are interrelated and not excessively redundant. This effort deals with one aspect of this Air Force R&D; namely, the methodology available to link enlistment standards to the job performance measures developed.

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I. INTRODUCTION

The Joint-Service Job Performance Measurement/Enlistment Standards Project (or JSP for Joint-Service Project) has two goals: (a) to investigate the feasibility of developing measurement methodologies to assess military job performance accurately and efficiently and (b) to link enlistment standards directly to job performance once the measures are available (Harris, 1987). As it becomes increasingly clear that the first objective is feasible and job performance measurement methods become available, interest turns to the second objective. This paper is motivated by such interest.

The linkage process has been described and justified in the context of improved quality and utilization of the enlisted force as follows:

1. A definitive link between enlistment criteria and job performance will enable us to determine accession _quality_ requirements with greater precision than is now possible (Harris, 1987);

2. Hard evidence on the relationship between job performance and _quality_ standards will allow us to justify our recruiting resources on the grounds of improved performance on the job (Armor, 1987);

3. "Linking enlistment standards to job performance can have several interpretations . . . . Many of us have now become convinced of a larger meaning (larger than validation of selection tests) for linking enlistment to job performance. Linking implies providing a _meaning_ to the _scale_ of job performance beyond simple ranking of examinees . . . to assist policy makers in setting entrance standards . . . . Given the strong competition for manpower, reasonable and defensible decisions about personnel allocation depend on knowing the resultant job performance that would be experienced. Different choices (cutoff scores) would lead to better performance in some jobs, not such good performance in some other jobs . . . . There is no standard way to make such comparisons . . . no

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accepted solution. You are at the edge of the current scientific methodology." (Green & Shavelson, 1987, p. 352); and

4. " I don't believe that there is any system that is so good that it can't be improved. One of the reasons that we're doing the Job Performance Measurement Project is so we can improve the way we select and classify young people into the military. If we sit back on our laurels and say that the system is working OK, then we're not ever going to do it any better. I am philosophically opposed to that notion" (Sellman, 1987, p. 419).

There are several important and recurrent themes in these characterizations:

1. Linkages can improve decisions regarding the needed quality of accessions by tying enlistment criteria to the quality of job performance;

2. Linkages will allow recruiting resource budgets to be justified in terms of improved performance on the job;

3. Linkages can assist classification decisions about how to allocate talent (resources) across jobs; and

4. Linkage implies giving meaning to job performance scales so that the consequences of lowering (or raising) cutoff scores can be explained to policy makers in terms of impact on performance on the job and thus on mission effectiveness.

The purpose of this paper is to consider available cost/performance modeling techniques that can provide the linking mechanism for using the job performance measures to address manpower policy issues such as those stated above. The focus is thus methodological; more specifically, the focus is on linking methodologies. It is assumed that the measurement system developed and applied by the Air Force as part of the JSP is fundamentally sound, meeting traditional standards of reliability and validity. In short, it is outside the scope of this paper to address the nature of the Air Force measurement system in depth. However, every attempt will be made to avoid treating linking mechanisms in a vacuum; rather, the quality of the inputs needed from the measurement system in order to obtain useful and comprehensible outputs from a linkage model will be carefully examined. Similarly, the expected utility of linking methods for Air Force manpower policy making will be examined in the context of the

current Air Force standard setting process. Thus, what the linking models require from job measurement methods will be addressed along with how the current process might implement and benefit from cost/performance modeling techniques.

To achieve these goals, a two-pronged information gathering approach was used in this study. Literature in the three major areas relevant to the goals of the study was reviewed; namely, job entry standards, job performance measures, and enlistment-performance linkage models. Secondly, interviews were conducted with personnel in key Air Force offices involved in recruiting, selecting and classifying enlisted personnel.[1] Results of these efforts will be reported and synthesized in the four major sections that follow. First, the current Air Force standard setting/implementation will be described and results of the author's interviews reported (Section II). Next, the potential interplay of the job performance measurement project and the model building process will be treated (Section III). Third, available mechanisms for achieving the interplay (i. e., linkage models) will be reviewed and critically evaluated (Section IV). Finally, major findings will be synthesized and recommendations for future work will be proposed (Section V).

II. CURRENT AIR FORCE QUALITY STANDARDS PROCESS

How Standards Are Set

An understanding of how Air Force enlisted standards are currently set (and adjusted) is, of course, fundamental to the goals of this effort. A review of key documents in the area yielded a graphic characterization of the Air Force enlistment/classification organizational hierarchy. The chart shown in Figure 1 is taken from Waters, Laurence, and Camara (1987, p. 34) and is intended to reflect how the system handles problems that may signal the need for standard adjustments. During the author's interviews with Air Force personnel presently involved in recruiting, selecting, and classifying activities, this chart was used to stimulate discussion (see the

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[1]   Details regarding the special purpose interviews are provided in Appendixes A and B and annotated references for corollary research that bear on the linkage of enlistment standards to measures of job performance are presented as Appendix C.

	Level 4	OASD/FM&P/AP ◄── USMEPCOM
Policy Manage- ment	Level 3	AF/DPXOA ◄── HQ/AF/Staff Agencies
Problem Analysis	Level 2	AFMPC/DPMRTC ◄── AFHRL
Problem Identifica- tion	Level 1	MAJCOM Personnel or Training AF/DPPTS Recruiting Service Retention/ Reenlist- ment
		ATC/TT
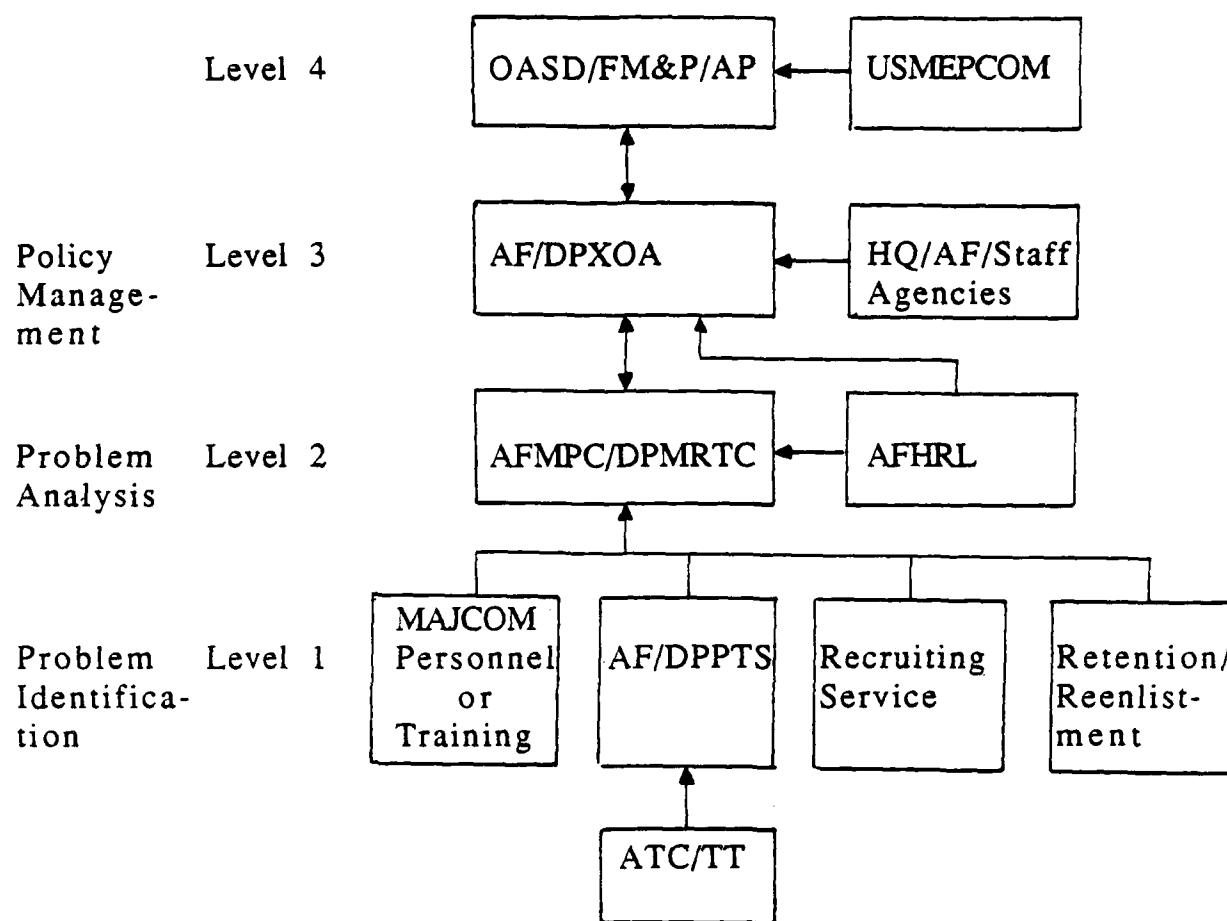
Key: AFMPC/DPMRTC   HQ USAF Classification and Training Branch
AF/DPXOA   HQ USAF Accessions and Reenlistment Policy Branch
AFHRL   Air Force Human Resources Laboratory
ATC/TT   Air Training Command Technical Training
AF/DPPTS   HQ USAF Systems/Specialist Training Branch
OASD/FM&P/AP Directorate for Accession Policy in the Office of the Assistant Secretary of Defense (Force Management and Personnel)
USMEPCOM   U. S. Military Entrance Processing Command

Note. From Waters, Laurence, and Camara (1987, p. 34).

Figure 1. Air Force Selection and Classification Standards Management.

Questionnaire in Appendix B for details). Participants in the interviews provided solid verification -- with only minor modifications -- regarding the accuracy of this structure.

The multistage process moves from initial identification and analysis of selection/classification-related problems (Level 1 and 2) to the culminating policy decisions (Level 3) that are monitored by an officer in the Department of Defense (Level 4). More specifically, existing enlistment standards, which are set forth in Air Force Regulation (AFR) 39-1, are reviewed when "problems" in the field are encountered. Problems may involve events such as difficulties in meeting eligibles, for example; increased attrition in training courses as a function of changes in training curricula; adverse trends in reenlistment; and complaints from the field about unsatisfactory job performance. Other events that might trigger a review of standards might include research and development (R&D) efforts being carried out by the Air Force Human Resources Laboratory (AFHRL) in areas such as job learning difficulty, or initiatives such as Rivet Workforce that would require the restructuring of Air Force specialties (AFSs). These influences on the process may be surfaced by recruiters, trainers, personnel in the major commands, researchers, Air Staff, or others. After the identification stage, such problems are channeled to an Air Force functional manager, who is responsible for the specialty in which the problem exists (Level 2/Problem Analysis). The functional managers collect information, analyze the situation, and decide what action(s) to take.

In making these determinations, the functional managers should keep in mind that aptitude requirements serve many purposes. In addition to the major functions of screening candidates for enlistment and matching persons to jobs, other functions of aptitude requirements -- identified by Maginnis, Uchima, and Smith (1975a) as being equally important -- include such areas as career development, assignment flexibility, and job/service satisfaction. If aptitude requirements are set too low, abundant manpower for the Air Force may be available, but training problems and poor job performance may result. If aptitude requirements are set too high, the available manpower pool might be limited, and underutilization and job dissatisfaction may result. In either case, career development, retention, and classification are affected. In their three-volume report, Maginnis et al. (1975a, 1975b, 1975c) traced the history of Air Force aptitude levels and their impacts on the personnel system. The authors pointed out that "expert judgment" apparently played a large part in the original setting of aptitude minimums for entry into specific AFSs. They then described the impacts of aptitude requirements in several hypothetical situations; i. e., "Set 1" where aptitude levels are set higher-

than-optimal for entry-level job performance effectiveness, "Set 2" where aptitude scores are set lower-than-optimal, and "Set 3" where aptitude levels are set equal-to-optimal. Impacts are expressed in terms of the manpower pool; recruitment, selection, and enlistment; classification and assignments; training; job performance; job satisfaction and morale; promotion and transfer; and retention. Comparisons of impacts revealed that selection using lower-than-optimal requirements shows more negative impacts than does selection using higher-than-optimal requirements. Results of the Maginnis et al. (1975a, 1975b, 1975c) research are mentioned here to illustrate the availability of information and procedures (at least hypothetically) to assist functional managers and offices in the current standards setting process.

The Classification and Training Branch at the Air Force Military Personnel Center (AFMPC/DPMRPQ) is the focal point and key office for coordinating AFR 39-1 (enlisted) and AFR 36-1 (officer) changes. An extensive coordination package is developed and the coordination process begins. Offices that are involved in the coordination loop include the following:

HQ AFMEA/MEXR	(Air Force Management Engineering Agency-provides coordination on manpower implications)
ANGSC/MPP	(Air National Guard Service Center-ensures appropriate Air National Guard coordination)
HQ USAF/REP	(Air Force Reserve Personnel-ensures appropriate Air Force Reserve coordination)
HQ AFMPC/DPMR	(Air Force Military Personnel Center-provides airmen and officer assignments coordination)
HQ USAF/DPPP	(Air Staff-provides coordination on force programs [Trained Personnel Requirement])
HQ USAF/DPPTF	(Air Staff-provides coordination for flying specialties)
HQ USAF/DPPTS	(Air Staff-provides coordination for nonrated specialties)
HQ USAF/DPXOA	(Air Staff-provides accessions and airmen reenlistment policy coordination)

HQ ATC/TTSA	(Air Force Air Training Command-provides training and recruiting coordination)
HQ AFMPC/DPMAPA	(Air Force Military Personnel Center-provides coordination for programs management)
HQ USAF/DPPH	(Air Staff-provides coordination for human relations, strength and aptitude requirements, and woman issues)
HQ AFMPC/DPMRPP	(Air Force Military Personnel Center-provides assignment policy coordination)
HQ USAF/DPXF	(Air Staff-provides coordination for force structure plans)
HQ USAF/DPXOP	(Air Staff-provides promotions and career force coordination)
HQ USAF/DPXE	(Air Staff-provides entitlements coordination)
HQ AFMPC/SGM	(Air Force Military Personnel Center-provides medical and physical standards coordination)
AFOSP/SPP	(Air Force Office of Security Police-provides security and security clearance coordination)
HQ AFMPC/DPMRAS	(Air Force Military Personnel Center-provides skills management and retraining coordination)
HQ AFMPC/DPMRC	(Air Force Military Personnel Center-provides coordination on issues pertaining to E-9s [Chief Master Sergeants])
HQ AFAAMRL/HEB	(Air Force Armstrong Aeromedical Research Laboratory-provides coordination for strength and aptitude requirements and new AFSCs)

Action taken by the various offices within the coordination chain depends on the nature and priority of the problem involved. Conceivably, a Request for Personnel Research to AFHRL might be initiated, if the problem warranted research attention. One methodology available to the various offices within the elaborate coordination process is based on the theory of occupational learning difficulty. This methodology, described by Weeks (1984), can be used to evaluate aptitude requirement minimums

for Air Force enlisted specialties. A basic assumption of the method is that aptitude (i. e., aptitude minimums) and learning time (i. e., task learning difficulty) are related. A standardized measurement procedure, described by Burtch, Lipscomb, and Wissman (1982), uses occupational survey data collected by the the Air Force Occupational Measurement Center to derive indices of occupational learning difficulty for each specialty. Such measures provide an empirical, job-centered frame of reference which can be used to determine the relative order of aptitude requirement minimums and support other critical management decisions. Results of occupational learning difficulty R&D by AFHRL have led to aptitude requirement adjustments which were accomplished and published in the 1982 revision of AFR 39-1.

Examination of the above list of agencies reveals the scope and impact of standard setting in the sense that most aspects of the life cycle of the enlisted forces are included in the coordination process; i. e., recruiting, classifying, training, assigning, promoting, utilizing, etc. Once this lengthy coordination phase is complete, the results are forwarded to the "Policy Management/Level 3" (HQ USAF/DPXOA) for final approval before eventual implementation. At this point in the process, the proposed aptitude minimum is customarily reviewed again for consistency and reasonableness in terms of AFR 39-1. Also, any additional statistical data which might aid in the more accurate setting of standards, such as current estimated distributions of the available manpower pool, would be considered at this time.

Given the scope and implications of the process described above, one could imagine that it would be useful to the offices involved to have a means by which the consequences of various policy decisions could be projected and evaluated. For example, if standards were raised by 10 points for an entire career field, or even for a given AFS, what impact would the decision have on the recruiting quotas for the rest of the force? What would be the impact on recruiting cost, if the goal were to increase the number of high ability personnel? And what about the impact on training? Decision modeling techniques could conceivably serve a very useful purpose during standard setting by allowing the various consequences of such decisions to be determined and evaluated for acceptability before implementation. The case for modeling cost and personnel outcomes becomes even stronger during times of limited resources when both personnel and financial resources are at risk. The case becomes stronger yet if one examines the impact of less-than-optimal standards on later stages in the classification-training pipeline. The impact on classification is examined next.

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Implementation of Enlistment Standards
in the Matching of Personnel to Jobs

Each year approximately 56,000 enlisted personnel are selected and classified into roughly 300 occupations in the Air Force. Two computer-based systems accomplish this staggering task. The first, the Procurement Management Information System (PROMIS), is a pre-enlistment system which processes nonprior-service recruits from the time they become interested in joining the Air Force until the time they enter basic military training (BMT). The second, the Processing and Classification of Enlistees (PACE) system is a post-enlistment system which classifies enlistees during BMT.

The basic concept of PROMIS and PACE is to select and classify airmen by optimally assigning them to jobs, given their particular aptitudes at the time of entry and the goals and constraints of the Air Force expressed in terms of the training slots, manpower authorizations, etc. A decision modeling technique called policy specifying (Ward, 1977) was developed at AFHRL to achieve the optimal person-job match (PJM). The technique takes variables identified as pertinent to the Air Force systems -- including aptitude indicators and training/job openings -- and combines them into a single "payoff value" for a given recruit. A payoff value indicates the worth to the Air Force of classifying a recruit into a particular job. The PJM process is summarized in Figure 2.

Both PROMIS and PACE take as givens the aptitude scores from "Personnel Files" (as shown in Figure 2) and the job entry requirements from "Job Files" and then process them to maximize the payoff values of incoming personnel through optimal assignments. The "payoff algorithm" shown in Figure 2 uses the policy specifying methodology to compute payoff values that reflect current Air Force judgments concerning individual job assignments. A separate equation for each job is used by the algorithm to compute a payoff value for each individual recruit for all available jobs. These payoff values are the key inputs for the actual assignment of personnel to jobs, which takes place next in the "assignment algorithm." For a more thorough discussion of the PJM algorithm refer to Ward (1977). It is in the computations of the payoff values that the minimum standards described in the previous section play an important role. Both enlistment standards and individual aptitude indicators are used as key decision variables in the mathematical models and equations used to derive payoff values. The use of these payoff values enables the Air Force to better match personnel graduating from BMT with AFSs based on a policy defined

```
 ┌─────────────┐              ┌─────────────┐
 │ Personnel   │              │  Job        │
 │ Files       │              │  Files      │
 └──────┬──────┘              └──────┬──────┘
        │                            │
        └──────────┐      ┌──────────┘
                   ▼      ▼
          ┌─────────────────────┐
          │  Payoff             │
          │  Algorithm          │
          └──────────┬──────────┘
                     ▼
          ┌─────────────────────┐
          │  Payoff  Values     │
          │  for Each Recruit   │
          │  on Each Job        │
          └──────────┬──────────┘
                     ▼
          ┌─────────────────────┐
          │  Assignment         │
          │  Algorithm          │
          └──────────┬──────────┘
                     ▼
          ┌─────────────────────┐
          │  Optimally          │
          │  Assigned Personnel │
          │  (Maximize Payoffs) │
          └─────────────────────┘
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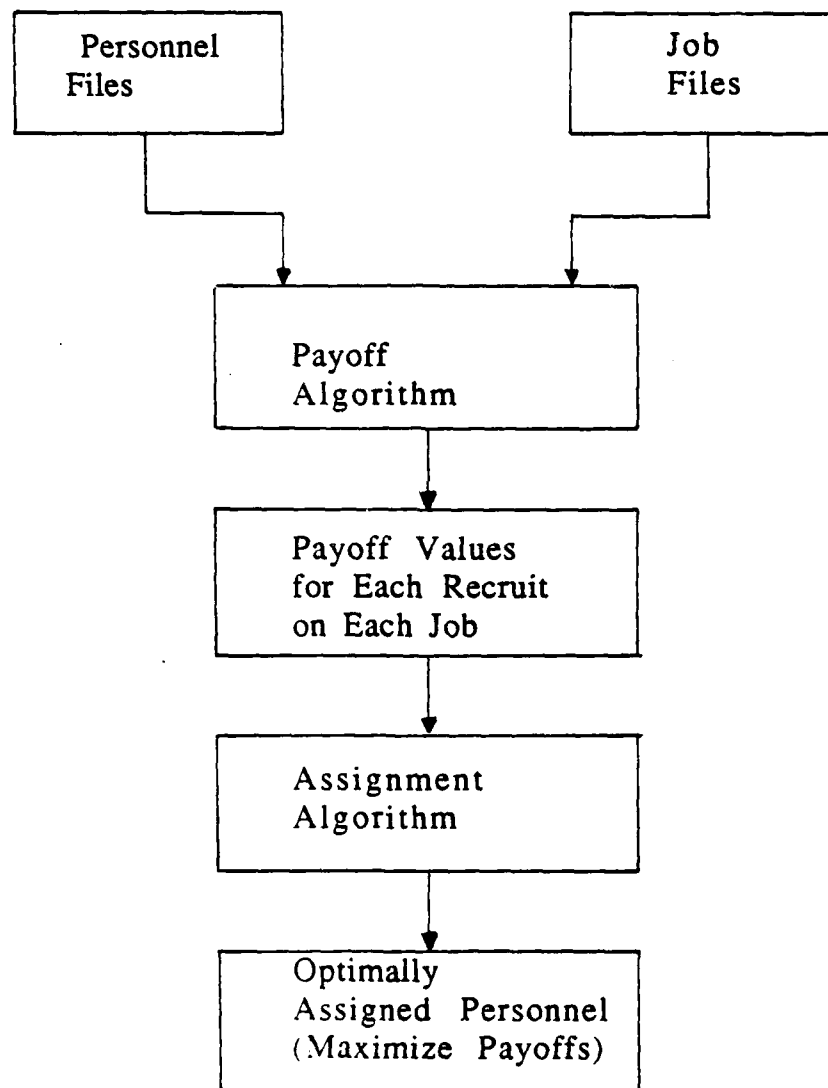
Figure 2. The Person-Job Match Process.

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by Air Force policy makers. In addition, the PJM process plays an important role in the distribution of aptitude levels (quality) in a particular specialty. An algorithm that deals with the standard setting process for AFSs should take this actual resultant distribution into account when considering the supply of available candidates.

The Need for Linkage Models
to Improve the Quality of Air Force Accessions

Given the selection and classification procedure previously described and the fact that the Air Force has within recent years been satisfactorily meeting all of its needs in terms of both quantity and quality of accessions (recruits), some have questioned the basic need for linkage models to improve the selection process. In this vein, there are those who would argue that because the Air Force is presently in an optimal recruiting position, the system either perfectly selects to ensure competence or screens out any false positives that might be erroneously selected. To those that hold this view, the Joint-Service Job Performance Measurement/ Enlistment Standards Project is probably seen, first and foremost, as a means by which this optimal state of affairs (i. e., highest quality recruits and no incompetents on the job) is verified. To them, the JSP purpose is to "prove that what we're doing now is OK . . . the answer at the end (of the research) is (to be) a check mark, (that) everything's fine" (Strickland, 1987, p. 413). Their interpretation of linking enlistment standards to job performance would be a linkage model that simply computes a validity coefficient between predictor (the Armed Services Vocational Aptitude Battery [ASVAB]) and criterion (job performance) measures.

Other levels of interpretation are also possible, however. They range from the position supported by Harris (1987), which is to determine accession quality requirements with greater precision than is presently possible; to that implied by Armor (1987) and Sellman (1987), which is to justify the need and associated costs for high quality accessions in terms of impact on job performance; to that embraced by Green and Shavelson (1987) and others on the National Academy of Sciences Technical Oversight Committee to the JSP. In the latter view, a linkage model should be used to improve selection and classification decisions and to generally give meaning to job performance scales by explaining both the requirements that account for competent job performance and the chain of relationships between the aptitudes tapped by selection tests and the performance demands encountered by personnel (after training) on the job.

In the next two sections of this paper, linkage approaches will be described that would seem appropriate, given these various interpretations, or goals. First, the common elements in candidate linkage models and the model building process in general will be discussed.

III. THE LINKAGE MODEL BUILDING PROCESS
WITHIN THE JOINT-SERVICE PROJECT (JSP) FRAMEWORK

The four linkage methodologies to be presented in Section IV share certain common elements and fundamental processes, such as optimization formulations. The common elements include the _output_ or the specific objective(s) to be accomplished, the criteria (e.g., constraints) to be invoked in meeting those objectives, and the _input_ or data elements to be linked (e.g., aptitude and job performance measures). These elements will be described in this section in the context of a model building scheme.

Identification of an Appropriate Objective
and Optimization Criteria

For most of the linkage models considered in this paper, the nature of the _output_ is the same; namely, an enlistment standard (or set of standards) as a cutoff score for selection decisions. The manner in which the cutoff score is derived computationally is a function of the parameters included in the linkage model. In turn, the objective or purpose to be met by the linkage model fundamentally drives the selection of model parameters. Possible objectives for the Air Force in this regard might include the following:

1. To determine the _validity_ of _ASVAB_ aptitude measures as predictors of actual performance on the job;

2. To determine what _levels_ of _ASVAB_ performance will predict various _levels_ of job _performance_;

3. To determine what levels of ASVAB performance will predict various levels of job performance at specified _costs_; and

4. To derive the optimal allocation of personnel across Air Force specialties in terms of cost and utilization of talent.

Optimization criteria related to these objectives generally concern factors such as cost, performance or productivity, mental quality (aptitude), time, and force size. For example, candidate optimization goals might be:

1.   To maximize the <u>quality</u> of performance;

2.   To minimize <u>costs</u> to achieve an <u>acceptable</u> level of performance quality;

3.   To minimize <u>time</u> (in training and experience) to achieve an acceptable level of performance quality;

4.   To minimize force <u>size</u>; or

5.   To maximize return on (personnel) investment (ROI).

Maximizing performance quality can be interpreted as building the most capable force. In order to produce realistic results, this criterion must be constrained to provide a ceiling on force cost. In addition, the user may wish to set other constraints such as force size and experience levels.

A minimum cost procedure, in contrast, will require constraints on both performance and force size in order to assure some acceptable level of capability. As before, experience levels can also be constrained. Minimizing force size will generally produce the same results and similarly requires constraints to provide lower limits on both capability and experience.

The final criterion, ROI, is a hybrid of cost and performance. It can be formulated either to maximize benefit per unit of cost such as productive unit/dollar or, the inverse, to minimize cost per unit of benefit (i. e., cost/productive unit). The results are equivalent in either case. The advantage of using a cost/ benefit criterion is that the issues of performance (effectiveness) and cost (efficiency) are addressed directly in the objective function rather than through constraints, thereby assuring a broader range of feasible solutions. The difficulty in formulating constraints in these variables lies in determining adequate or acceptable levels. The ROI formulation is generally preferred in this context since decision makers are presented with the most efficient "product" per unit

benefit (i. e., the most "cost effective" solution). Additional capability may then be "purchased" at an easily identifiable marginal cost if it is required.

From the Air Force's perspective, the preferred optimization would likely mean establishing the highest quality force that is reasonably attainable. From Congress' perspective, optimization would likely mean minimizing costs to man a mission-capable force. For the Air Force to defend its need for specific quality standards at certain levels of cost, it is necessary, according to some viewpoints, to articulate how mission capability and thus readiness are affected by lowered standards (Armor, 1987; Sellman, 1987). This requirement in turn dictates certain types of input variables as performance measures.

The Input Data Elements and Empirical Linkages

Inputs to standard linkage models can be loosely grouped into two general categories -- cost factors and individual capability factors. In the first category, factors such as the costs of recruiting, training, and maintaining the enlisted force are relevant, as well as costs expressed as "time to proficiency" or rate of experience gains. Typical objective functions involve minimizing costs such as these, while maximizing the capability factors in the second category (e. g., productivity and aptitude). Measures of aptitude are available as ASVAB composites. Measures of job performance, expressed as level of productivity or proficiency, must be obtained. Also, the empirical linkages between the aptitude and performance measures are important to the meaningfulness and comprehensibility of the outputs obtained from the various linkage models. The issues related to job performance measures as input and their empirical linkages to enlistment standards are considered next.

Types of Job Performance Measures

Given the variability in the objectives or purposes to be served by linking enlistment standards to measures of job performance, different types of job performance measures are applicable. In the previous section where objectives were discussed, two general goals were established:

1. To validate the ASVAB against measures of on-the-job performance; and

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2. To determine the relationship between different levels of ASVAB scores and different levels of job performance so that enlistment standards can be:

    a. made more precise,

    b. justified in terms of impact on job performance (and thus mission), and

    c. optimized so as to minimize costs while fielding a capable enlisted force.

If goal 1 is selected by the Air Force, then the inputs required as measures of job performance can be either:

1. Norm-referenced test scores expressed as percentiles (as are ASVAB composites) indicating an airman's relative ranking with respect to others tested, or

2. Criterion-referenced test scores expressed as the airman's degree of mastery of the job (i. e., the "criterion being referenced").

For example, goal 1 could presumably be achieved by simply correlating norm-referenced ASVAB scores with norm-referenced job performance measures, such as scores on the Walk-Through Performance Testing (WTPT) component (Hedge & Teachout, 1986). If the validity coefficient is acceptable according to some prespecified standard (e. g., significantly greater than zero), then the validation purpose of goal 1 is achieved.

However, if the coefficient or set of coefficients is viewed as low, which is a possible interpretation of results reported in a recent study by Dickinson, Hedge, and Ballentine (1987), then the results may require further explanation. Given the well-entrenched position of the ASVAB in military selection procedures, the probable interpretation of such low validity coefficients would be to indict the job performance tests. On the other hand, the relationship between ASVAB predictors and job performance criteria could be further investigated. In addition, a more precise characterization of the relationship between ASVAB components and performance test results for specific areas of job content would assist in the future development of valid aptitude tests. The following example is offered to make the point more concrete.

Dickinson et al. (1987) reported eight specific areas of technical proficiency for the jet engine mechanic specialty, which were derived through analyses of occupational survey data and judgments from subject-matter experts:

1. Complete forms;

2. Prepare engine for storage/shipping;

3. Inspect engine;

4. Remove/replace engine components;

5. Conduct quality control inspections;

6. Perform engine maintenance in shop environment;

7. Perform engine maintenance on flightline; and

8. Troubleshoot engine malfunctions.

If the present performance data set on the jet engine mechanics permitted, job area subtest scores could be computed for airmen on these individual job content areas or on logical composites of the areas listed above such as 1-2, 3-5, or 6-8. This approach is one of several recommended by Wigdor and Green (1986, p. 57) to better understand ". . . the chain of relationships between the abilities tapped by selection tests and performance, after training, on the job."

Analyses to relate ASVAB predictors to job performance criteria expressed as job content area subtests could reasonably be expected to provide valuable information for aptitude test development. For example, given the patterns of correlations reported by Dickinson et al. (1987) and the known academic nature of ASVAB and technical school measures (i. e., academic in the sense that general verbal and quantitative components are heavily weighted), it seems reasonable to expect stronger relationships between ASVAB scores and our jet engine subtests denoted 1 and 2, and possibly 3 and 4, than with other job areas. In job areas 1-4, one would expect performance demands to be largely the following of routine, well-established procedures that would logically be predicted by general verbal and quantitative competencies (i. e., ASVAB scores). On the other hand, general academic competencies may not predict complex problem solving skills in specialized subject-matter domains, such as required by the

troubleshooting and shop/flightline maintenance content areas (subtests 6-8). Tasks in those subdomains are often ill-structured, meaning no well-specified procedures for solution are available (Gott, Lesgold, & Glaser, 1987).

With this finer-grained validity approach, a reasonable outcome might be sufficiently high correlations between ASVAB scores and performance in certain job areas (e.g., 1-4), and low correlations in others. Areas where the relationships are low would suggest that there are performance demands (or behavioral requirements, to use a term from the National Academy of Sciences Committee) associated with the job that do not map well onto traditional aptitude indices. In point of fact, it is this very hypothesis that has motivated AFHRL's Learning Abilities Measurement Program (LAMP). The goal of that program (Kyllonen & Christal, 1988) is to develop a theory of learning ability that would lead to new selection measures to supplement the ASVAB in order to improve its predictive validity, especially in Air Force specialties where information processing demands are heavy.

If goal 2 is selected by the Air Force, then the inputs required as measures of job performance should be criterion-referenced test scores. Mastery scores by definition use a scale that gives meaning to the performance data because an individual's degree of mastery of the specialty in question is estimated. Without such a scaling of performance scores, it would be impossible to model and estimate the impact that a change in enlistment standards would have on job performance capability.

To summarize, while norm-referenced job performance tests will satisfy the basic linkage goal (goal 1) of validating the ASVAB, the interpretability of low correlations, should they occur, would be problematic. Further clarification of the relationship between ASVAB and performance criteria could be gained by generating performance subtest scores in specific job content areas and using such performance scores to validate present or proposed aptitude tests. This approach would provide invaluable information for those attempting to develop future aptitude tests that predict on-the-job performance. Certain job content areas may be predicted quite well by ASVAB scores, suggesting that the right aptitude constructs are being tapped in the recruiting population. Conversely, other areas may be poorly predicted, suggesting the need for research such as the LAMP program to improve selection measures. On the other hand, to determine the relationship between different levels of ASVAB scores and job performance (i. e., setting enlistment standards), criterion-referenced scoring is recommended.

Empirical Aptitude-Performance Linkages

The foregoing account argues for aptitude-performance linkages that can be supported either theoretically or logically. Finding relationships between aptitude tests and performance criteria can serve to strengthen the validity of ASVAB as a predictor of job performance and suggests the need for more detailed investigation of the aptitude-performance relationship. Detailed investigations of the relationship between job content areas such as completing forms or troubleshooting faulty engines and the underlying skills and abilities sought in the recruit population serve to identify areas for future aptitude-job performance R&D. Establishing the relationship between job mastery and recruit aptitudes allows enlistment standards to be justified in terms of how airman performance would be adversely impacted by lowered standards (Armor, 1987; Sellman, 1987). Perhaps more importantly, military quality requirements can be better understood if job proficiency can be precisely tied to selection tests. This goal requires a combination of efforts to maximize the way existing tests (ASVAB) predict job mastery and to develop aptitude tests that better predict job proficiency.

Criteria for Evaluating Linkage Models

The previous discussion presented the various goals the Air Force might pursue through linking enlistment standards to performance measures, as well as the elements and processes shared by available linkage models. Given that discussion, it is now possible to propose a set of criteria to use as a basis for model evaluation.

First, the Air Force must decide which goal is to be served in the linking of selection standards to job performance. Model parameters are dictated by whether the goal is to compute a simple validity coefficient or to do more elaborate analyses requiring cost and benefit factors. The acceptability of the model to the Air Force, as well as its ultimate implementation, are directly related to how well the model serves its intended purpose(s). Accordingly, model evaluation is meaningful only in terms of how well it meets the stated purpose(s).

Once the goal is established. it becomes possible to evaluate each model with respect to the specified goal as well as against additional general criteria as follows:

1. What is the quality of the required inputs and are they easily obtainable?

2. Are the computational requirements associated with the model (including optimization processes) efficient and flexible?

3. Does the output serve the stated purpose? Is it easily interpretable?

To illustrate how these general criteria would apply in specific cases, several examples are presented.

1. Example No. 1: GOAL is ASVAB job performance validation only. This example falls at the low end of the complexity continuum with respect to model parameters and computational requirements. As proposed earlier in this section, norm-referenced ASVAB scores would provide suitable input as predictor variables, and norm-referenced job performance measures would be suitable as criterion scores. Computational requirements are minimal since what a simple validation model entails is the calculation of a validity coefficient as output. The validity coefficient would establish the predictive validity of the ASVAB and thereby meet the model's stated purpose. The output would not reflect the quality of job performance associated with various levels of aptitude; thus, the interpretation of the predictor-criterion relationship would be very circumscribed.

2. Example No. 2: GOAL is to determine enlistment standards for a given job that minimize the cost of achieving given levels of job performance. This example falls at the high end of the complexity continuum with respect to model parameters and computational requirements. Required inputs would include the levels of job performance to be attained (e.g., minimally acceptable score on a job performance test); the associated aptitude scores; and various cost estimates covering recruiting, training, and force maintenance/retention. Many of these input variables might be difficult to obtain; e. g., the minimal level of acceptable job performance (especially if only norm-referenced test data were available) and the costs of recruiting.

The evaluative framework described previously will be applied to the specific models reviewed in the following section.

IV. REVIEW OF LINKAGE METHODOLOGIES

Four major techniques have been identified as having potential applicability to the Air Force's linkage objective(s): expectancy charts, break-even analysis, a time to proficiency model, and the Rand cost/performance tradeoff model.

Expectancy Charts

Description

The institutional expectancy chart method is one of two possible linkage techniques described by Cascio (1987) in a paper prepared for the Committee on the Performance of Military Personnel. The basic objective of the method is to depict the likelihood of "successful" job performance being attained by individuals at various aptitude levels. Probabilities are computed using the predictor and criterion scores of some known cohort; thus, it is assumed that predictor-criterion relationships will remain constant with future cohorts. Various proportions of individuals meeting a range of ASVAB minimum scores are related to probabilities of success on the job, as illustrated in Figure 3.

The expectancy chart method seems appropriate for an Air Force goal such as the following: "to determine the relationship between different levels of ASVAB scores and different levels of job performance to justify enlistment standards in terms of impact on mission capability." For example, expectancy charts would provide the basis for an argument to the effect that dropping a minimum aptitude score from 85 to 70 would mean a 10% decrease in personnel who can meet minimal levels of job proficiency. A required input is thus criterion-referenced job performance measures. For this method, the required inputs, the computational processes to be used, and the resultant outputs are as follows:

Inputs Required

1. ASVAB scores for known cohort of job incumbents;

2. For same incumbents, job performance scores that reflect extent of job mastery; and

Group	Minimum Score	Percent Who Demonstrate Minimal Level of Competency	
Best 20%	85		90
Best 40%	70		80
Best 60%	53		70
Best 80%	40		60
All	25		50
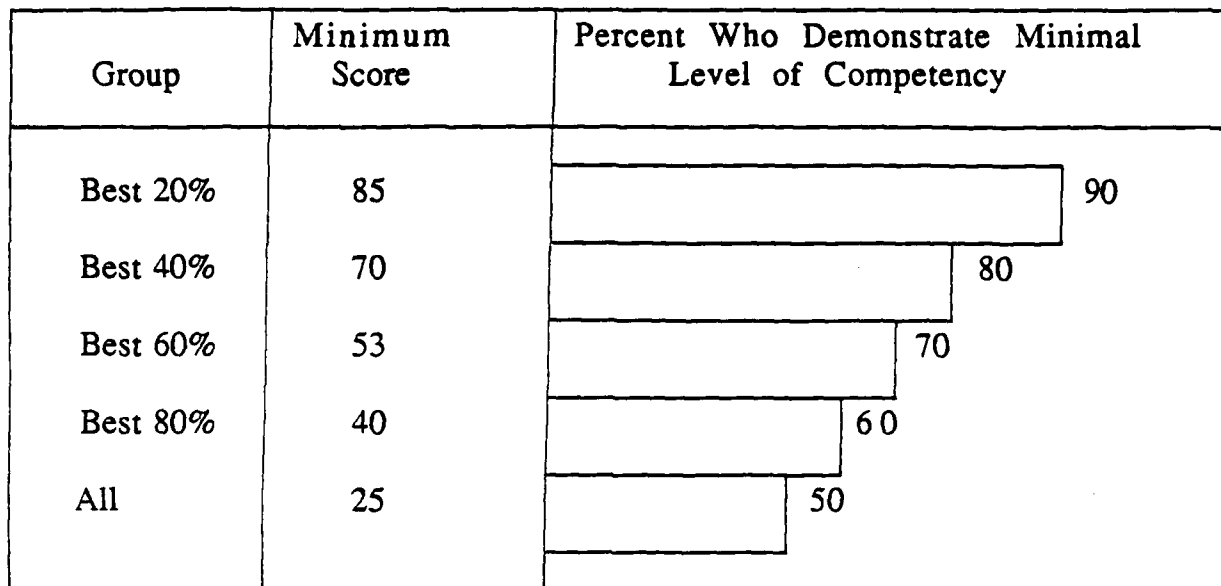
Figure 3. Institutional Expectancy Chart Illustrating the Likelihood of Successful Criterion Performance at Different Levels of Predictor Scores.

3. Minimal job mastery level set by and acceptable to policy makers.

Computational Processes

1. Compute validity coefficient between ASVAB (predictor) scores and job performance (criterion) scores;

2. Map the various levels of ASVAB performance (top 20%, 40%, etc.) onto a corresponding set of minimum ASVAB scores; and

3. Maximize force quality by estimating likelihood of successful job performance (according to prespecified minimally acceptable standard) from any given level of aptitude.

Outputs

1. Probabilities of minimally acceptable job performance associated with various aptitude levels; and

2. Range of potential aptitude cutoff scores and associated impact on mission due to adjustment in selection standards.

Evaluation Results

The required inputs for expectancy charts constitute the principal limitation for this method. Meaningful output depends on job performance measures that reflect extent of job mastery (or proficiency). There are also several assumptions underlying the required inputs that are somewhat restrictive. First, the relationship between predictor and criterion scores is assumed to be constant over time. This assumption could be periodically tested in revalidation studies, however. Secondly, a minimally acceptable level of job mastery is assumed as a standard of performance. If policy makers are reluctant to set such a standard, various levels could be modeled (as in Cascio examples) for purposes of demonstrating the expectancy chart technique. Finally, cost factors as inputs are missing, thereby limiting the information value of results; however, cost factors are not implied in the purpose this method is intended to serve. With respect to the other criteria:

1. The output serves the stated purpose;

2. The results are easily interpretable; and

3. The computational requirements are reasonable.

Break-Even Analysis

Description

Break-even analysis was the second method described by Cascio (1987) and in this method he incorporated cost parameters. The basic objective of the method is to determine the minimum aptitude level (i. e., enlistment standard) that will allow recovery of the dollars invested in recruiting, selecting, inducting, training, and monetarily reimbursing a specified quota of personnel until minimally acceptable job performance is achieved. This method is a form of the ROI approach.

The method uses the general utility equation which has the following general parameters: costs of developing a recruit into a minimally satisfactory job performer or costs associated with some specified time period

(C); the length of time to be allowed to recover investment costs (T); the value of job performance expressed in dollar terms (SD_y); estimated number of new recruits required in some future time period (N); the correlation of predictor and criterion scores for a known cohort of job incumbents (r_{xy}); and the average standard score ($\bar{Z}$) on the aptitude test required to break even over the specified time period. In the general utility equation, one solves for $\triangle U$ as a payoff value. In this application $\triangle U$ is set to 0 dollars and the equation is solved for $\bar{Z}$ to derive a minimum break-even aptitude score.

The equation is defined as:

$$\triangle U = N * T * r_{xy} * SD_y * \bar{Z} - N * C$$

$\triangle U$ = $0.00; the point at which gains due to improved job performance are exactly equal to investment needed to reach minimal competence

N = the specified quota of new recruits in some future time period

T = the length of time available to recover investment (Cascio proposes either the first term of military service or the average tenure of personnel)

r_{xy} = the validity coefficient of aptitude and job performance measures

SD_y = the standard deviation of job performance in dollars

$\bar{Z}$ = the average standard score on the selection procedure required to break even over the time period (T) specified. ($\bar{Z} = \lambda /SR$ where λ is the ordinate of the normal curve corresponding to the selection ratio [SR] used)

C = the total amount of money invested in each recruit in order to bring that recruit up to a level of minimally acceptable job performance or to complete some specified time period of enlistment

A numerical example to illustrate the use of the equation was given by Cascio (1987, p. 32-33) where N = 10,000 recruits; T = 4 years; r_{xy} =

0.40; SD_y = \$15,000; and C = \$20,000. Solving the equation yields $\bar{Z}$ = 0.83 and a selection ratio of 0.20. Therefore, the "solution" is to use a cutoff score which would identify the top 20% of the examinees.

Break-even analysis seems appropriate for an Air Force goal such as: "to use the relationships between ASVAB and job performance scores to derive enlistment standards that ensure the Air Force's investment in personnel is recouped during their enlistment." For example, break-even analysis would provide the basis for an argument to the effect that a given enlistment standard must be met if the goal is to get a payback (in terms of airman performance contribution) that is equivalent to the Air Force's dollar investment in the airman at the point of separation.

For break-even analysis, the inputs, computational process, and outputs are as follows:

<u>Inputs Required</u>

1. ASVAB and job performance measurement scores for cohort of job incumbents (can be either norm-referenced or criterion-referenced tests);

2. r_{xy}: the validity coefficient of aptitude and job performance measures in a known cohort of job incumbents, corrected for criterion unreliability and range restriction;

3. C: all costs associated with recruiting, induction and processing, initial and advanced training (where applicable), and salary and other benefits during Air Force tenure or during period needed for minimal proficiency to be reached. If the break-even point is to be associated with reaching minimal proficiency as opposed to completing some period of enlistment, then a minimal proficiency level must be set by and acceptable to policy makers;

4. T: specfied time for recovery costs;

5. SD_y to use as a metric to express the worth of an airman's contribution to the Air Force during a specified time period; and

6. N: required number of personnel.

Computational Process

1.   Solve for $\bar{Z}$ to derive a minimum aptitude score to achieve a "break-even" return on investment.

Outputs

1.   An aptitude cutoff score that will allow airman costs and performance payback during enlistment to be equivalent; and

2.   Byproduct outputs such as cost figures used as inputs.

Evaluation Results

As with expectancy charts, the required inputs for break-even analysis constitute the principal limitation for this method. The fundamental goal of making costs and benefits equivalent in dollar terms assumes that airman job performance can be meaningfully represented in terms of dollar value to the organization (usually expressed as salary). Although there has been some work done to derive more appropriate indicators of the value of job performance in military contexts, estimating performance worth remains a problematic issue for any cost-benefit method that uses a dollar metric.

Regarding other input variables, it is possible to implement the break-even approach using norm-referenced job performance test scores. The resulting cut-score output can be interpreted only in terms of specifying the level of aptitude needed for the Air Force to recoup its investment costs for a recruit. With norm-referenced criterion measures, the derived cut-score does not provide any information regarding the selection standard needed to achieve certain levels of quality in job performance.

With respect to other model evaluation criteria:

1.   The output serves the stated purpose;

2.   The results are easily interpretable; and

3.   The computational requirements are reasonable, assuming meaningful measures of SD_y (or its equivalent) can be established.

Time to Proficiency (TTP) Model

Description

The time to proficiency approach (Carpenter & Monaco, 1987) uses a productivity measure to establish the value of performance output rather than using a dollar metric as seen in Cascio's break-even approach. (Cascio [1987] also proposed as an alternative to SD_y, SD_p, which is defined as the standard deviation of output expressed as a percentage of mean output. The TTP approach is conceptually similar to Cascio's SD_p.) The objective is to determine the aptitude cutoff score that minimizes cost per productive unit of performance.

The approach features the notion of "time to proficiency"-- defined as the length of time it takes to bring people with different attributes (e. g., mental aptitude) to targeted levels of proficiency (i. e., productivity). Given the basic parameters of productivity, costs, and aptitude indices, this approach seems appropriate to an Air Force objective such as linking aptitude and performance (which, in the TTP model, is represented as productive capacity) to minimize costs while fielding a capable enlisted force. Stated differently, the TTP approach finds "those levels of aptitude requirements that best balance work force capabilities and costs" (Carpenter & Monaco, 1987, p. 1). Characterized in this manner, TTP has an ROI objective similar to break-even analysis. The major difference is in the metric used to represent capabilities of the force. Break-even analysis uses a dollar metric (SD_y) whereas TTP represents capability as work units com-pleted per unit of time.

To accomplish the objective of minimizing cost/productive unit, the TTP approach examines the functional and logical relationships of four components: aptitude, productivity (work output), cost, and attrition. In overview terms, productivity is represented as a function of performance time, experience, and aptitude. Distributions of aptitude scores are used so that probability density functions can be computed for subpopulations of airmen defined by level of aptitude. Costs are represented as recruiting, training, and salary costs through the first term. Attrition is represented as the likelihool of remaining in the service for each month in the first term of enlistment as a function of aptitude.

Basically, production and cost are accumulated over the first term and adjusted for attrition to yield expected first-term productive capacity (the inverse of performance time) and expected first-term cost. The ratio of expected cost to expected productive capacity is then computed for aptitude subgroups to determine the subgroups with the lowest average cost per productive unit for the first term. The mathematical representations of the four models that are integrated to form the TTP model are described next.

The productive capacity model is defined as

$$P = 1 / (1 + \exp[-b_0 - b_1 x_1 - b_2 x_2])$$

where

$P =$ productive capacity

$x_1 =$ experience (months in AFS)

$x_2 =$ mental aptitude index (e.g., ASVAB electronics score)

b_0, b_1, and b_2 are parameters to be estimated.

The productive capacity, P, is defined as t^*/t, where t^* is an estimate of the fastest possible performance time in which a defined unit of work can be completed at an acceptable level of quality (based on supervisors' ratings of subordinates' relative required times for acceptable task completion). For any individual worker, t is the time required for that worker to satisfactorily complete the defined unit of work. For the individual, 1/t is the number of work units he or she can complete per unit of time. Thus:

$P = t^*/t = (1/t) / (1/t^*)$ is the proportion of maximum productivity that the individual has obtained (Carpenter & Monaco, 1987). Further, this model assumes that airmen with higher aptitudes are more productive than are airmen with lower aptitudes and that productivity increases with experience.

The attrition model is defined as:

$$r(x, t) = b_0 + b_1 \ln[(t + s(x)) / (48 - t)] + b_4 x$$
where r(x,t) is the probability of an airman with an aptitude index of x remaining in service after t months (t = 1 to 48)

$x =$ mental aptitude index (e.g., ASVAB electronics score or E-score)

$t =$ time in service (months)

$s(x) = \exp(b_2 + b_3 x)$

b_0, b_1, b_2, b_3, b_4 are parameters to be estimated.

Once estimated, the above productive capacity and attrition models are integrated into a meaningful objective function. To develop this function, it is helpful to first consider two intermediate functions -- expected productive capacity and expected cost. The ratio of expected cost to expected productive capacity provides the desired index of cost per productive units of performance. Expected first-term productive capacity for an individual with a given E-score of x can be described by the following equation:

$$P(x) = \sum_{t=0}^{48} r(x,t)\, p(x,t)$$

where $P(x) =$ Expected first-term productive capacity for an individual with E-score of x

$\qquad x =$ E-score

$\qquad t =$ time in service (months)

$\qquad r(x,t) =$ probability that an individual with E-score of x is still in service after t months

$\qquad p(x,t) =$ productive capacity for an individual with an E-score of x and t months of experience.

Expected first-term cost for an individual with a given E-score can be described by:

$$C(x) = \sum_{t=0}^{48} r(x,t)\, c(x,t)$$

Where $C(x) =$ Expected first-term cost for an individual with an E-score of x

$$x = \text{E-score}$$

$$t = \text{time in service (months)}$$

$$r(x,t) = \text{probability that an individual with E-score of } x \text{ is}$$
$$\text{still in service after } t \text{ months}$$

$$c(x,t) = \text{cost to the Air Force of an individual with E-score } x$$
$$\text{in month } t.$$

The ratio $C(x)/P(x)$ represents the expected cost per productive unit over the first term. By minimizing this ratio with respect to x (E-score), one can determine the optimum E-score to minimize cost per productive unit.

At this stage of the minimization problem, the formulas imply that all new recruits should be selected with an E-score equal to the optimum value of x. It would, of course, be impractical to impose such a constraint on the selection of airmen for a given AFS. The distribution of aptitude scores of the pool from which new recruits are selected must be considered. If $f(x)$ is the probability density function of E-scores for the population of potential recruits, then

$f_m(x) = f(x)/(1- \sum\limits_{i < m} f(i))$ is the conditional probability density function for the population of potential recruits with an E-score of at least m. Productive capacity and cost can then be modeled as functions of a minimum allowable E-score (as opposed to an optimum).

$$E[P(m)] = \sum\limits_{x \geq m} f_m(x) \; P(x)$$

$$E[C(m)] = \sum\limits_{x \geq m} f_m(x) \; C(x)$$

Where: m is the minimum allowable E-score

$E[P(m)]$ is the expected (average) first-term productive capacity for the subpopulation of potential recruits with E-scores of at least m

$E[C(m)]$ is the expected (average) first-term cost for that subpopulation

$f_m(x)$ is the conditional probability density function of E-scores for the subpopulation of potential recruits with E-scores of at least m

$P(x)$ and $C(x)$ are as defined earlier.

By minimizing the ratio $E[C(m)]/E[P(m)]$ with respect to m, one can find the optimum minimum E-score standard for a given distribution of E-scores among a recruiting pool.

The inputs, computational processes, and outputs for the TTP Model are as follows:

Inputs Required

o   Productive capacity model:

1. t^*:   estimate of smallest possible time interval in which a defined unit of work can be satisfactorily completed (based on supervisor ratings);

2.   t: time required for a given worker to satisfactorily complete the defined unit of work;

3. x_1:   months' experience in the AFSC (by worker);

4. x_2:   aptitude score (by worker); and

5.   Distribution of aptitude scores of the pool of possible recruits.

o   Attrition model (only those inputs unique to this model are listed):

6. $r(x, t)$:   probability of an airman with an aptitude of x remaining in the service after t months (t = 1 to 48).

o   Cost model

7.   C: first-term costs using average recruiting and training costs and military pay.

Computational Processes

1. Estimate productive capacity as the inverse of performance time;

2. Estimate expected productive capacity by adjusting productive capacity for attrition effects; and

3. Minimize cost per productive unit of performance (i. e., benefit) by computing the ratio of expected cost to expected productive capacity.

Outputs

1. An optimum aptitude standard that minimizes cost per unit of production; and

2. Byproduct outputs such as

    a. Cost figures used as inputs,

    b. Expected productive capacity of an individual with a given aptitude score at a given point in his/her career, and

    c. Predicted attrition rate by aptitude score.

An optimal solution using the TTP model is illustrated in Figure 4 (from Carpenter & Monaco, 1987), where the computed expected cost per productive unit (vertical axis) is shown for subpopulations defined by different electronics score cutoffs (horizontal axis). In this example, the lowest average cost is associated with an electronics score cutoff of 90 (bar at far right). Under a different cost model, the solution might change. For example, using a different cost model reflecting increased recruiting costs and military pay for higher aptitude groups would influence the solution in the direction of choosing a lower aptitude subpopulation. An example of such a solution is shown in Figure 5 (from Carpenter & Monaco, 1987), where the costs for the highest subpopulation (i. e., cutoff of 90) have been increased by 9%. As a result, the lowest average cost per productive unit in this case is obtained for a lower subgroup; namely, the group with a cutoff of 80.

	3967	3774	3578	3407	3264

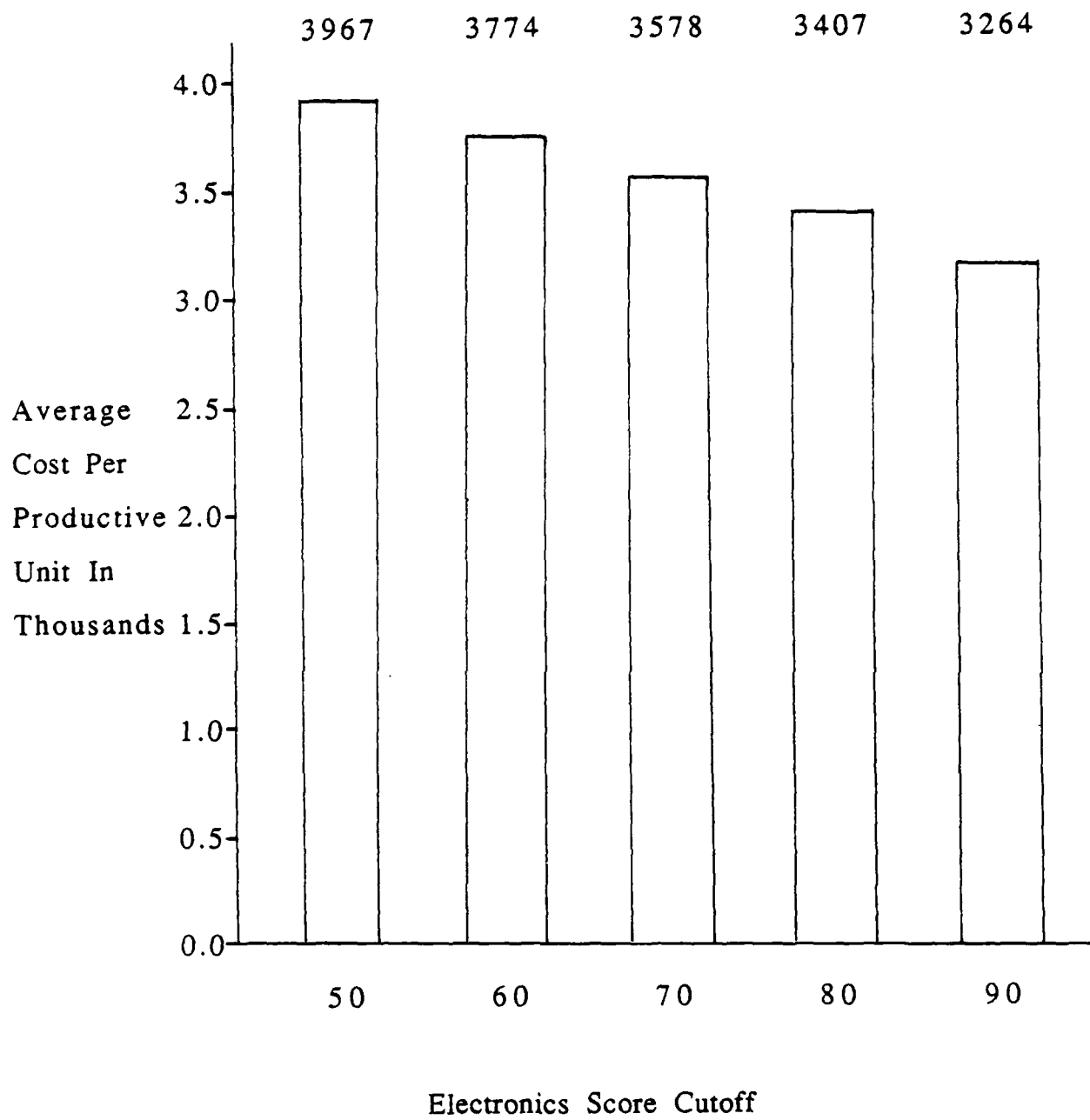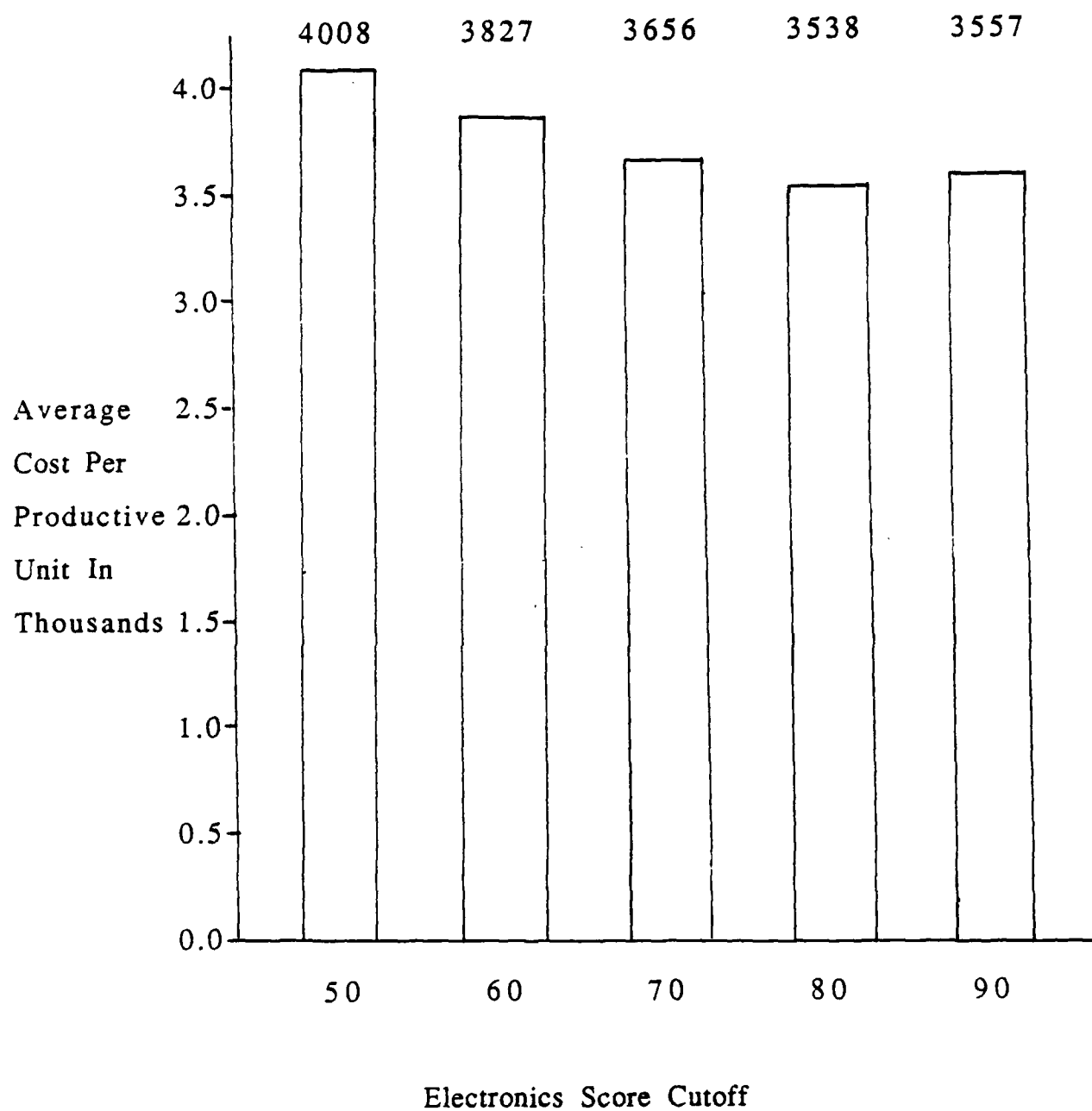Average Cost Per Productive Unit In Thousands

Electronics Score Cutoff

Figure 4. Average Cost Per Productive Unit.
(Carpenter & Monaco, 1987)

Figure 5. Average Cost Per Productive Unit with 9%
Cost Increase (Carpenter & Monaco, 1987)

Evaluation Results

Quality/Obtainability Of Required Inputs. A potential benefit associated with the TTP model is that it does not require criterion-referenced job performance measures as inputs, as contrasted to most other approaches (break-even analysis is the other exception). In fact, this approach does not use available JSP job performance measures directly; however, the Walk-Through Performance Test was used to assess the TTP as a surrogate. In the TTP procedure, performance is estimated by time to proficiency ratings provided by supervisors. The collection of the job performance inputs for this approach therefore requires a moderate degree of effort. A documented procedure exists for collecting TTP data and developing surrogate job performance measures; however, to date this has been accomplished on only one AFS. Required inputs to the attrition and cost models are reasonably obtainable, although some recruiting costs are difficult to estimate.

There are additional important caveats to be stated regarding any form of personnel ratings provided by supervisors. As Wigdor and Green (1986) noted, supervisor ratings are known to be contaminated by personal attitudes such as personality preferences. On the plus side, however, Carpenter and Monaco (1987) established limited validity for the supervisor ratings obtained in their study of one AFS. In addition, other measures of time to perform would work equally well in the TTP approach (e.g., the JSP's hands-on performance time).

A final comment is offered on the quality of TTP indices: They are norm-referenced in the sense that time requirements (for completion) are represented for a group of workers in relation to one another. That means that the production or productive capacity indicators depict proficiency in a relative sense, not in an absolute sense that would explain whether the units of production that are estimated represent 95% of the job or 50%, for example.

Other Evaluative Criteria. In terms of computational efficiency and flexibility, the TTP approach has been satisfactorily tested on an Air Force data set to verify the "workability" of the modeling process. In terms of interpretability of the output, Figures 4 and 5 illustrate the comprehensible way in which it is possible to represent findings, even though the model building leading up to the results is involved and intricate.

Finally, in terms of the suitability of the output, given the stated goal, the TTP approach does allow one to determine "those levels of aptitude

requirements that best balance work force capabilities and costs"
(Carpenter & Monaco, 1987, p. 1). The work force capabilities that are
utilized are norm-referenced and therefore they assume that present
members of the enlisted force meet implicit standards of competence,
making it unnecessary to represent performance in terms of extent of job
mastery. Further, this approach does not explain the empirical linkages
between concrete behavioral job requirements and aptitude constructs, as
favored by the National Academy of Sciences Committee. However, that
dimension is not part of the goal to which this approach responds.

The Rand Model

Description

By far the most extensively documented linkage model is the Rand
cost/ performance tradeoff model (Armor, Fernandez, Bers, &
Schwartzbach, 1982). The basic objective of this method is to derive
optimal enlistment standards and ability mixes (among personnel) by
calculating force-cost figures for a given level of job performance. As a
cost effectiveness approach, it serves the purpose of determining the
"enlistment standards for a given military job that minimize the cost of
achieving given levels of job performance" (Armor et al., 1982, p. 14). In
treating "levels of performance," the Rand model features the notion of
qualified man-months (QMMs). It is the period of enlistment during which
a performer functions at a qualified (versus unqualified) level. The mile-
stone that distinguishes between the two levels is the meeting of a mini-
mal standard of proficiency on a job performance test such as the Army's
Skill Qualification Test (SQT). Months in service after passing a test such as
the SQT are regarded as QMMs.

To accomplish the stated objectives, the Rand approach integrates a
performance model and a cost model to yield force-cost estimates (as
inputs) to produce the desired output; namely, ability mixes that mini-
mize force cost per QMM. In the performance model, a minimum standard
is set for a job performance test such as the Army's SQT. As noted earlier,
months in service after passing the SQT are regarded as QMMs.

In order to ensure that end-strength or necessary manpower levels
are met in the calculation of QMMs, a constraint on the model is typically
invoked whereby a predetermined number of retained man-months

(RMMs) must be met. The number of RMMs essentially reflects needed manpower to fill established quotas.

To summarize, numbers of QMMs yielded by various ability mixes are modeled as a function of personnel entry characteristics such as aptitude and (for Army applicants) high school completion. The cost model then estimates the cost of recruiting and maintaining various levels of a qualified force in terms of ability mixes at time of entry. The mathematical representations of the models that are integrated to produce the desired output are described next. Since the Rand approach has been developed and tested on Army populations, discussions are necessarily in that context.

The __performance__ model produces as output __QMMs__. A simple accounting function relates QMMs to two major enlistment characteristics: high school completion and aptitude level (expressed by Armor et al. [1982], as enlistment categories I through IV). The remaining parameters are functions of those entry characteristics found to predict basic training completion (B), advanced training completion (T), retention (R), and SQT performance (S).

QMMs are computed using the following expression:

$$QMMs = A \sum_{i} [P_i B_i T_i \sum_{t} (R_{it} S_{it})] \tag{1}$$

where

$i =$ category of entry characteristics (e. g., high school graduate in enlistment category II)

$t =$ time in service in months

$A =$ number of accessions

$P_i =$ proportion of accessions in category i

$B_i =$ proportion of category i accessions completing basic training

$T_i =$ proportion of category i basic graduates completing advanced training

$R_{it} =$ proportion of category i advanced graduates completing t months of service

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S_{it} = proportion of category i retained accessions able to pass the SQT at month t

The objective of the Rand's <u>cost model</u> is to impose cost figures on the previously defined performance model to make the output more meaningful; i. e., to establish the <u>cost</u> of recruiting and maintaining a given qualified force (as implied in equation 1). Together the performance and cost models can be used to investigate ability mixes that minimize force costs per QMM. In this sense the Rand and TTP approaches are similar since they both seek "minimal costs for productivity attained" (here productivity is months of service at a qualified level; with TTP, productivity is work units completed per unit of time).

Force costs for a given ability mix fall into the following categories according to Armor et al. (1982, p. 18): (a) the cost of recruiting, including advertising and special enlistment benefits and bonuses offered to high ability personnel (C_A); (b) cost of initial entry and basic training (C_B); (c) cost of advanced training in a specific job (C_T); and (d) cost of the retained force in the post-training period, including pay, allowances, and base support activities (medical, commissary, recreation, etc.) (C_R). Of these, the cost of recruiting is considered the most difficult to estimate. Total cost of recruiting and maintenance is merely the sum of these four component costs:

$$C = C_A + C_B + C_T + C_R \qquad (2)$$

Two variations of integrating the performance and cost models -- RAND-1 and RAND-2 -- have been proposed by Armor et al. (1982). The objective being modeled and the constraints invoked are different in each.

In RAND-1, RMMs are constrained to a fixed level (to meet manpower quotas) and the cost per QMM is minimized. The <u>formula</u> for <u>RRMs</u> is shown below. The job performance SQT parameter has been removed; otherwise the formula is the same as equation 1:

$$RMMs = A\sum_i [P_i \; B_i \; T_i \sum_t (R_{it})]. \qquad (3)$$

The <u>RAND-1 model</u> for cost <u>minimization</u> as constrained by fixed manpower requirements (represented by RMMs) is illustrated below (from May & Mayberry, 1986). For purposes of illustration, personnel are divided into two groups -- high quality (h) and low quality (l).

$$\text{Minimize} \frac{C(M_h(s), M_l(s))}{Q(M_h(s), M_l(s))}$$

Subject to $M_h(s) + M_l(s) = RMM^*$

where

$C =$ total cost

$Q =$ number of QMMs

$M_h =$ number of RMMs for high-quality recruits

$M_l =$ number of RMMs for low-quality recruits

$s =$ aptitude cutoff score

$RMM^* =$ fixed number of RMMs

In <u>RAND-2</u>, the number of QMMs is held constant and total cost is minimized, but force size is allowed to vary. This variation greatly limits the utility of RAND-2.

The required inputs, computational processes, and outputs for the RAND-1 and RAND-2 models are as follows:

<u>Inputs Required</u>

● Performance model

1. A: total number of accessions to be considered;

2. P: proportions of accessions in given aptitude categories;

3. B: proportions of accessions completing basic training (by aptitude category);

4. T: proportions of basic training graduates completing technical training (by aptitude category);

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5. R: months of service (t) completed by technical training graduates (by mental category); and

6. S: proportion of retained accessions able to pass a job performance test such as the SQT (by aptitude category and month of SQT passed) -- includes minimally acceptable job performance test score.

- Cost model

7. C: sum of force costs to include recruiting (C_A), initial entry and basic training (C_B), technical training (C_T), and force maintenance (C_R).

Computational Processes

1. Estimate quality of performance for aptitude subgroups in terms of the number of months an individual performs at a "qualified" level (meaning a minimal proficiency standard has been met);

2. Ensure fixed manpower requirements are met (in RAND-1) by constraining cost minimization computations so that necessary total man-months are achieved; and

3. Minimize cost per qualified unit of performance (i.e., benefit).

Outputs

1. An optimum aptitude standard (cutoff score) and associated aptitude mixes that minimize cost per qualified unit of performance;

2. Numbers of qualified personnel achieved with optimal standard and associated costs; and

3. Byproduct outputs such as

   a. Alternative standards and associated aptitude mixes, numbers of personnel, and associated costs; and

   b. Cost figures used as inputs.

An example of the type of information obtained from the processing of the Rand model using Army data is displayed in Table 1. Note that as the cutoff score is moved from a low value of 70 upward to a high value of 115 the ability mix with regard to education and mental category changes considerably. For example, the number of high school graduates in categories I-IIIA is 8,513 at the 115 cutoff level versus 2,902 at the 70 cutoff level. However, costs are higher at the 115 level (i. e., $2,503 per QMM versus $2,260). Examination of the cost per QMM column reveals the minimum to be located at a cutoff score of 85. Thus, for this example, the desired cutoff score is 85.

Table 1. Rand Model Sample Output

Cutoff Score	Number of Accessions	HS I-IIIA	Non-HS I-IIIA	HS IIIB-IV	Non-HS IIIB-IV	Cost per QMM
115+	11,242	8,513	2,309	257	163	2,503
110+	11,331	7,796	2,689	495	351	2,397
105+	11,510	7,066	2,917	861	666	2,308
100+	11,644	6,434	2,930	1,364	916	2,247
95+	11,757	5,547	2,822	2,108	1,280	2,179
90+	11,756	4,732	2,572	2,965	1,487	2,142
85+	11,728	4,331	2,404	3,475	1,519	2,139
80+	11,651	3,747	2,144	4,252	1,507	2,153
76+	11,580	3,267	1,897	4,979	1,437	2,189
70+	11,523	2,902	1,709	5,529	1,384	2,260

Evaluation Results

Quality/Obtainability of Required Inputs. The Rand model pursues the same objective as the TTP approach and to some extent break-even analysis; namely, to minimize costs in achieving a qualified work force. For all three models the difficulty comes in defining the criteria of a qualified force. The input used to serve this purpose in the Rand model is a standard on a competency-based job performance test. Such a criterion measure is a problem for the time to proficiency approach and other norm-referenced testing programs. Presumably, norm-referenced tests could be used and arbitrary cutoff scores examined as illustrated in Table 1; however, outcomes would be difficult to interpret since the scores would not reveal adequacy of performance in any absolute sense.

There are several other factors related to the quality of Rand input variables that should be noted as well. First, the manner in which QMMs are computed assumes a dichotomous qualified versus unqualified performance variable. This is undesirable since relative performance differences are ignored, and the model thus favors the recruiting of individuals who score just above the cutoff rather than those higher scoring individuals who are assumed to be more expensive to recruit. A continuous measure of job performance might be preferable and should be tested with the Rand approach using Air Force data. Some preliminary work concerning the use of continuous measures for Army personnel has been undertaken by Armor (1985). Secondly, the distribution of personnel across aptitude categories in the cohort used in the analysis affects the outputs of the model. This so-called "proportionality assumption" presupposes that recruits in future cohorts will be similarly distributed so that ability mixes will remain similar to the "baseline" accessions group. The dependency of the Rand optimization procedures on the structure of the baseline group is illustrated with the following example. Suppose at the cutoff score of 75, four hypothetical groups of recruits had equal numbers or proportions: Group 1 = 25%, Group 2 = 25%, and Group 3 = 25%, and Group 4 = 25%. Suppose further that by increasing the cutoff score to 80, all Group 4 personnel would be eliminated. According to the proportionality·assumption, the new distribution of recruits would be Group 1 = 25/75 = 33 1/3%, Group 2 = 25/75 = 33 1/3%, Group 3 = 25/75 = 33 1/3%, and Group 4 = 0%. Thus, outcomes are dependent upon the choice of the baseline group.

Other Evaluative Criteria. In terms of computational efficiency and flexibility, the Rand approach has been tested on Army data and appears workable. The use of a continuous (versus dichotomous) job performance measure may be a useful way to further test the model's flexibility. The

model building process is somewhat intricate with the Rand approach, a condition which undoubtedly results in greater processing time when compared to simpler models such as break-even analysis. However, the output data are rich and presumably justify the requisite processing time.

In terms of interpretability of results, Table 1 illustrates a satisfactorily comprehensible array of findings. Finally, in terms of the suitability of the output given the stated goal, the results do reveal costs per qualified units of performance. The limitations revolve around defining just what those qualified units are and how the potential to achieve qualified status is distributed among a population of recruits.

Summary of Linkage Approaches

In the following table, the four models for linking aptitude and job performance are summarized in terms of the evaluative framework that was used in the previous sections: goal to be served by the linkage model, input/computational processes/output, and model strengths and weaknesses. The reader will notice a basic similarity in purpose across the four approaches; namely, to use the aptitude-performance relationship to improve decision making about the composition of the enlisted force. What distinguishes some approaches is that costs are factored into the decision making.

Table 2. Summary of Linkage Models

Model: Expectancy Charts

Objective:	To determine probability of job proficiency given level of entry aptitude
Air Force Goal:	To determine ASVAB-job performance relationships to establish impact of standards on mission capability
Primary Input:	Aptitude scores Competency-based job performance measures Minimal competency standard
Computational Processes Objective Function:	Maximize force quality by computing probabilities of job proficiency for given aptitude levels
Primary Output:	Probabilities of success for a given aptitude group Basis for justifying enlistment standards in terms of mission impact
Strengths/Limitations:	Competency-based tests and level of minimal competency required Computational demands low Results easily interpretable but limited in usefulness since cost information is not used

Table 2. (Continued)

Model: Break-Even Analysis

Objective: To determine aptitude levels that will yield equivalent personnel costs and benefits

Air Force Goal: To use ASVAB-job performance relationships to establish enlistment standards that ensure return on investment in personnel

Primary Input: Aptitude scores
Job performance scores (either norm- or criterion-referenced)
Personnel costs expressed in dollars
Personnel benefits expressed in dollars (e.g., salary metric such as SD_y)
Time to achieve return on investment

Computational
   Processes
Objective Function: Make return on investment (i.e., benefits to cost ratio) equivalent

Primary Output: Aptitude cutoff scores (enlistment standards) to achieve equivalence between personnel costs and performance benefits
Basis for justifying enlistment standards from return on investment monetary perspective

Strengths/Limitations: Cost information allows cost-benefit tradeoff analysis
Obtaining a dollar metric for performance benefits is problematic
Computational demands reasonable
Results interpretable assuming meaningful dollar metric for performance benefits identified

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Table 2. (Continued)

Model: Time to Proficiency

Objective: To determine aptitude cutoff that minimizes cost per productive unit of performance

Air Force Goal: To use ASVAB-job performance relationships to minimize costs while fielding a capable force; i.e., to balance force capability and cost

Primary Input: Aptitude scores
Supervisor estimates of performance expressed as the relative time to produce a satisfactory unit of work
Estimates of personnel costs
Attrition rates by aptitude group

Computational Processes
Objective Function: Minimize cost per productive unit of performance by computing ratio of expected cost to expected productive capacity (adjusted for attrition effects)

Primary Output: Aptitude cutoff scores (enlistment standards) that minimize cost per unit of production
Basis for justifying enlistment standards from cost-benefit perspective that does not require dollar metric to represent performance (benefits)

Strengths/Limitations: TTP avoids dollar metric problem (of Break-Even Analysis) but substitutes supervisory judgment approach that may have biases
Supervisor ratings are norm-referenced; thus, resultant productivity indices are relative to other performers, not job content
Computational feasibility of model previously demonstrated
Results interpretable but require caveats

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Table 2. (Concluded)

Model: Rand Cost/Performance Tradeoff Model

Objective:
To determine aptitude cutoff and ability mixes that minimize cost per qualified unit of performance

Air Force Goal:
To use ASVAB-job performance relationships to minimize costs while fielding a maximally qualified force

Primary Input:
Aptitude scores
Competency-based job performance measures
Minimal competency standard
Manpower requirements that must be met
Estimates of personnel costs

Computational Processes
Objective Function:
Minimize cost per qualified unit of performance

Primary Output:
Aptitude cutoff scores and associated aptitude mixes that minimize cost per qualified unit of performance
Basis for justifying enlistment standards from cost-benefit perspective that can express input in terms of lowered mission capability

Strengths/Limitations:
Competency-based tests and level of minimal competency required
When performance scores are treated as dichotomous variables, selection favors personnel near cutoff
Rich set of results produced: optimal and alternative enlistment standards and associated ability mixes
Computational feasibility of model has been demonstrated

V. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The general conclusions to be drawn from the previous evaluation are as follows:

1. The first step in pursuing the linking of aptitude to job performance is the key one. The Air Force must decide which among many possible goals it wishes to pursue:

    a. To validate ASVAB scores as predictors of job performance (<u>simple validation goal</u>);

    b. To determine what <u>levels</u> of ASVAB predict various levels of job performance (impact of standards on mission capability goal);

    c. To determine what levels of ASVAB predict various levels of job performance (mission capability) at specified <u>costs</u> (cost-benefit analysis goal); or

    d. To determine allocation of personnel across AFSs by optimizing cost-benefit ratios and utilization of talent (force structure cost-benefit goal).

2. Secondly, the goal-stating process is complicated due to Air Force institutional policy issues which are entirely separate from the methodological issues of model building. More specifically, although the interviews with policy makers that were conducted (in the course of developing this paper) revealed a definite need for a mechanism (such as a linkage model) to evaluate the consequences of the standard setting process, responses during interviews firmly established a low probability of use (and therefore impact) of linkage approaches in the near term. In short, the payoff of this AFHRL work will be limited until participants in the selection and classification system are sufficiently convinced of its merit to agree to adopt the proposed linkage mechanism.

3. Once the goal or set of goals is identified, available linkage models can be evaluated for suitability in terms of quality, requirements, and capabilities. For the four models reviewed in this paper, the value of the model results generally depended on the nature of the job performance measures that were used as input (i.e., norm-referenced or criterion-referenced scores). Norm-referenced job performance tests can be used in some linkage approaches, but for some goals such as 1(b)-1(d) above, results are not easily interpretable since the quality of job performance in some absolute sense is unknown (e. g., how much of the job content the airman has mastered). Some approaches have adopted a different conception of the quality of job performance (i. e., different from job content mastery) and attempted to use indicators such as the dollar value of performance and time to proficiency in lieu of criterion-referenced performance tests. Those approaches have been shown to have inherent limitations of a different type, however.

By way of a top-level concluding summary, Tables 3 through 5 are offered to evaluate available models against potential goals, using the criteria elaborated earlier in this paper. Following that, recommendations for future work in this area are proposed.

Table 3. Evaluative Comparison of Models Assuming Goal 1(b)

To determine impact of enlistment standards on job performance (mission capability)

| | Model | | | | |
Criteria	Exp Chart	B-E Anal[a]	TTP[a]	Rand Model[a]	Comments
1. Suitability of approach to goal	***				Last three models are overmatched to goal
2. Availability of needed inputs for Air Force application	*				Competency-based tests required as well as minimal competence standard
3. Quality of available inputs	*				Same comments as above
4. Processing efficiency/flexibility	***				
5. Usefulness of results	*				No cost information

Note. The extent to which models meet criteria are denoted as:

***	high
**	medium
*	low

[a]Model not appropriate for goal.

Table 4. Evaluative Comparison of Models Assuming Goal 1(c)

To determine impact of enlistment standards on mission capability in cost-benefit terms

| | Model | | | | |
Criteria	Exp Chart[a]	B-E Anal	TTP	Rand Model	Comments
1. Suitability of approach to goal		**	***	***	
2. Availability of needed inputs for Air Force application		**	**	**	SD_y a problem for B-E Anal; criterion-referenced measures a problem for TTP
3. Quality of available inputs		*	**	**	Same as above plus supervisor bias a problem for TTP
4. Processing efficiency/flexibility		***	**	**	
5. Usefulness of results		**	**	***	

Note. The extent to which models meet criteria are denoted as:

***	high
**	medium
*	low

[a]Model not appropriate for goal.

Table 5. Evaluative Comparison of Models Assuming Goal 1(d)

To determine impact of enlistment standards on mission capability in cost-benefit terms across AFSCs

Meeting this goal would require consequential extensions of the three approaches that involve cost-benefit analyses; therefore, all evaluation results have a high degree of uncertainty since the feasibility of such extensions is essentially unknown. As a result, indicators (high, medium, low) should be interpreted as probability estimates rather than conclusive assessments.

| Criteria | Model | | | | Comments |
	Exp Chart[a]	B-E Anal	TTP	Rand Model	
1. Suitability of approach to goal		*	***	***	Rand approach has been formulated
2. Availability of needed inputs for Air Force application		*	**	**	
3. Quality of available inputs		*	**	**	
4. Processing efficiency/flexibility		**	**	**	
5. Usefulness of results		**	***	***	

Note. The extent to which models meet the criteria are denoted as:

***   high
**   medium
*   low

[a]Model not appropriate for goal.

Recommendations

Based on the comparative evaluations presented in the prior two sections, recommendations for future work are as follows:

1. AFHRL should determine which linkage goal or set of goals to pursue based on criteria such as the following:

   a. Is the goal useful for the Air Force at large?

   b. Is the work involved in meeting the goal(s) justified in terms of "user support" from the manpower, personnel and training (MPT) community?

   c. Is the likelihood of success in meeting the goal(s) sufficiently high to warrant a sustained effort?

2. Once the goal state is specified, AFHRL should determine which linkage models are most applicable (by referring initially to tables 2 through 5) and proceed to examine known model weaknesses to assess the extent of the weakness; e. g., test the feasibility of using continuous (versus dichotomous) performance scores in the Rand approach using Air Force data. In addition, the following linkage model work is recommended:

   a. Using performance data from the eight Air Force JSP specialties, execute the models for linking standards to performance and conduct comparative analyses of the results.

   b. Determine procedures for assigning a dollar value to airman performance (as the benefit in a cost-benefit ratio) other than the standard deviation of salary metric (SD_y), which is typically used in the general utility equation.

3. AFHRL should also explore the feasibility of deriving ASVAB/ new predictor-performance test relationships for specific job content areas. Such analyses would help define ASVAB's ability to predict job performance and also help develop tests that predict performance.

4. Since the most serious limitation for most models concerns the nature of the job performance measurements (i. e., norm-referenced or criterion-referenced), some specific recommendations in this regard include the following:

    a. Explore methods for scaling performance scores to define job mastery, especially to define what constitutes minimally acceptable performance.

    b. Extend the TTP work to larger samples of AFSs, supervisors, and airmen to more rigorously examine issues of reliability and validity and the general defensibility of time to proficiency as a surrogate job performance measure. In addition, scaling TTP performance scores to achieve standardized criterion-referenced measures *is* required to have confidence that these data are useful for setting enlistment standards.

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APPENDIX A: PROCEDURES FOLLOWED IN DEVELOPING THIS PAPER

Relevant literature for this paper was identified through searches of the Defense Technical Information Center (DTIC), the published and unpublished reports of the Joint-Service Job Performance Measurement/ Enlistment Standards Project (JSP), and the available reports on Air Force Person-Job Match research efforts. The JSP literature includes papers prepared for the Committee on the Performance of Military Personnel/ National Research Council/National Academy of Sciences and all relevant RAND and Center for Naval Analyses (CNA) publications. Also included in the review are personal communications from JSP Working Group Meetings and similar occasions as well as relevant publications from the professional literature in the fields of psychometrics and personnel/industrial/ organizational psychology.

Sources from the literature were supplemented and verified by structured interviews with key Air Force personnel involved in the business of recruiting, selection, classification, and training. Interviews were based on a questionnaire that covered the following topics:

1. The enlistment/classification process as it works today;

2. The desired characteristics of a candidate linkage methodology that could improve that process;

3. The operational constraints that would affect the implementation of such a methodology;

4. Meaningful evaluation criteria for linking methodologies;

5. Completeness of sources identified for the literature review; and

6. Completeness of proposed offices/individuals for the structured interviews.

Offices where interviews were conducted are listed below and a copy of the questionnaire used as a basis for the interview follows.

Using the questionnaires described in the previous paragraph, structured interviews were conducted with various Air Force offices involved with the initial selection and classification process. Among those interviewed included key personnel at the following offices:

1. Air Force Recruiting Service (AFRS) working in the development and application of the Procurement Management Information System (PROMIS) and the Processing and Classification of Enlistees (PACE) system (Mr. Joe Manuel -- AFRS/RSR);

2. Air Force Military Personnel Center (AFMPC) working with job classification and assignments (Lt Col Dave Richmond, Jr. -- AFMPC/DPMRPQ; Capt Mike Begley -- AFMPC/DPMRPQ; Capt Wendy Campo -- AFMPC/DPMRPQ; Capt Doug Eads -- AFMPC/DPMRPQ; Maj Russ Seeman -- AFMPC/DPMYFX; Lt Col Rick Creekmore -- AFMPC/DPMRA; Capt Larry Letcher -- AFMPC/DPMRA);

3. Headquarters United States Air Force, Deputy Chief of Staff for Personnel, Directorate of Personnel Plans, Policy Division (HQ USAF/DPXOA) working with accession, selection, and classification policy, and the Air Force job performance measurement program (Lt Col Bill Strickland -- USAF/DPXOA; Lt Col Doug Gorman -- USAF/DPXOA);

4. Air Training Command (ATC) working with the PROMIS, PACE, training and policy-making process (Col Fraine Zeitler -- ATC/TTO; Lt Col Ed Cecconi -- ATC/TTPR; Maj Bill Cummings -- ATC/XPRR; Capt Bernard Aziu -- ATC/XPRR);

5. Office of the Deputy Assistant Secretary of Defense for Military Manpower and Personnel Policy (DASD/MM&PP) working with accession policy and joint-service job performance measurement (Lt Col Dickie Harris -- OASD/FM&P); and

6. AFHRL working with job performance measurement research and the selection, classification, and retraining process (Lt Col Dan Leighton -- AFHRL/MO; Lt Col Nick Ovalle -- AFHRL/IDE; Lt Col Rodger Ballentine -- AFHRL/ID; Capt Marty Pellum -- AFHRL/IDE; Capt Eric Duncan -- AFHRL/IDE; Dr. Manuel Pina -- AFHRL/MOMD; Mr. Larry Looper -- AFHRL/MOMD; Dr. Henk Ruck -- AFHRL/ID; Dr. Joe Weeks -- AFHRL/PR; Dr. Bill Alley -- AFHRL/MOT; Dr. Sherrie Gott -- AFHRL/MOMJ).

APPENDIX B: QUESTIONNAIRE USED FOR STRUCTURED INTERVIEWS

QUESTIONNAIRE

for

Exploratory Models to Link Job Performance
to Enlistment Standards

Contract: F41689-86-D-0052
Task: 0 9

Prepared for: Air Force Human Resources Laboratory
AFHRL/IDE
Captain Eric Duncan
August 17, 1987

Introduction

The purpose of this questionnaire is to collect information needed for the following: (a) to better understand the Air Force selection/classification process and the inherent organizational, operational, and policy limitations, (b) to develop meaningful criteria to evaluate existing technology and candidate models dealing with job performance measurement and accession attributes, and (c) to determine the feasibility of using such technology and models within the Air Force context.

Please fill in the following information and then read and answer the questions in the remaining sections.

Date: _____

Location: _____

_____

Time: _____

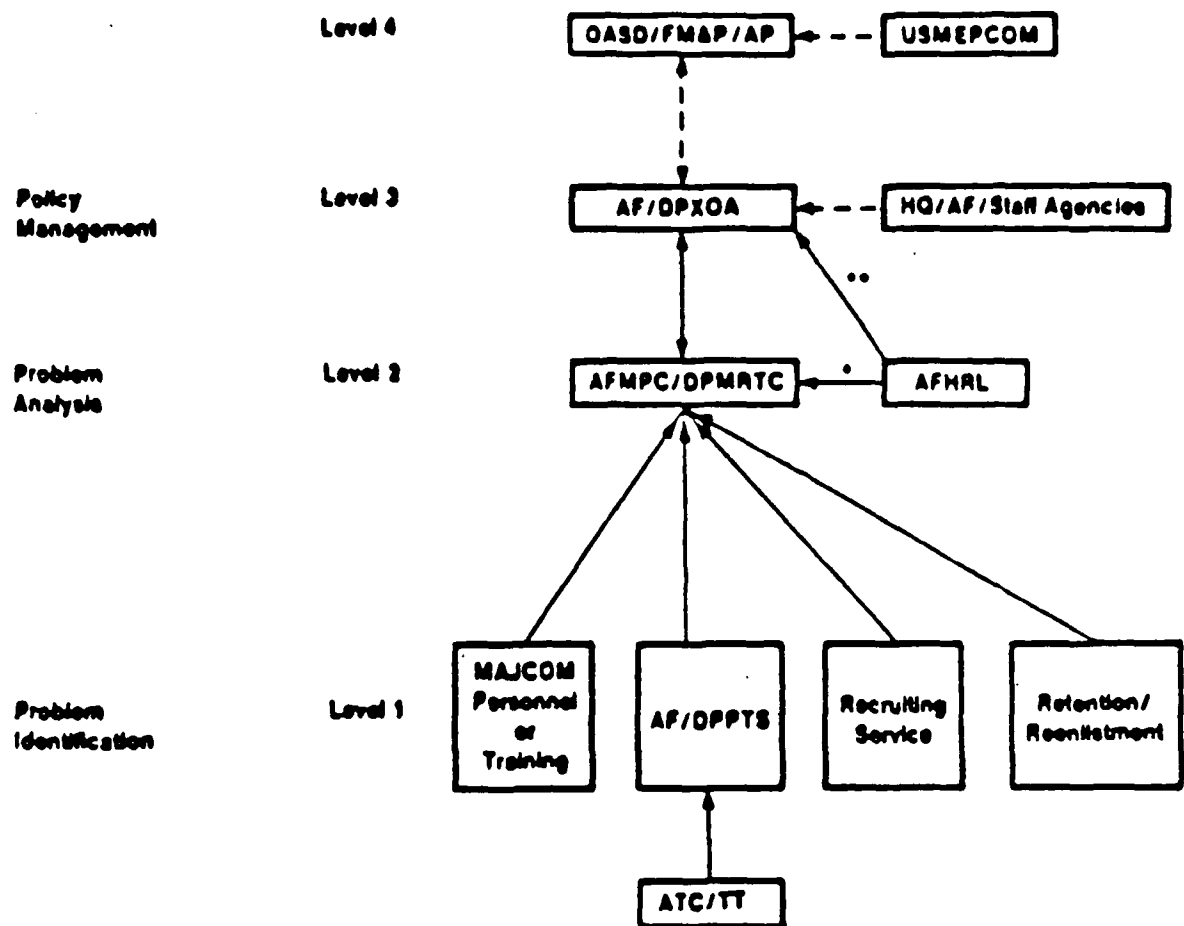Name and Office Symbol of Person(s) Responding to the Questionnaire:

_____

_____

Name of Person Conducting the Interview:

_____

QUESTIONS

1.   Brian K. Waters, Janice H. Laurence, and Wayne J. Camara recently prepared a paper entitled "Personnel Enlistment and Classification Procedures in the U. S. Military" for the Committee on the Performance of Military Personnel, Commission on Behavioral and Social Sciences and Education, National Research Council (National Academy Press, Washington, D. C., 1987).   In this paper, they describe the Air Force structure for accession policy management with the following description and figure:

> Figure 4 shows the Air Force system. The Air Force policy management level is the Accession and Reenlistment Policy Branch (AF/DPXOA) located in the Pentagon. As its name suggests, policy analysts in this office serve as the staff advisors to the Air Force Deputy Chief of Staff for Personnel on accession policy matters. The setting of standards for selection takes place in this office. The Accessions and Reenlistment Policy Branch (AF/DPXOA) coordinates closely with other Air Force headquarters staff agencies and DOD accession policy personnel. The Air Force OPR for classification standards is the Classification and Training Branch (AFMPC/ DPMRTC) at the Air Force Military Personnel Center.   . . . . .Like the Air Force, the responsibility for setting Army standards is delegated to that Service, yet is monitored by OASD/FM&P/AP.

Figure 4. Air Force Selection and Classification Standards Management.

Is this structure accurate? Yes ____ No ____ If no, what changes are recommended? (Make changes directly to Figure 4 if appropriate or list proposed changes in the following space):

_____

_____

_____

_____

Is the description accurate? Yes ____ No ____ If no, what changes are recommended? (Make changes directly to the description or list proposed changes in the following space):

_____

_____

_____

_____

2.   During the "Literature Review" phase of this effort, relevant documents were identified using the Defense Technical Information Center (DTIC), unpublished materials within the Department of Defense's Job Performance Measurement Project, publications from Rand and the National Academy of Sciences, and private literature sources. Approximately 25 of these documents were collected and are listed in Attachment 1. Please scan these references to evaluate the completeness of the literature search. Are there any other references which should be included? Yes ____ No ____ If yes, what additional references are recommended?

_____

_____

_____

_____

3.   For each of the major candidate models identified within the references, plans are to compile the following information:

   a.   Type of model
   b.   Summary and description of model/algorithm
   c.   Assumptions for use
   d.   Operational constraints and limitations
   e.   Inputs required
   f.   Outputs provided
   g.   Air Force data required: Data available? Continue to be available? Will data be available in the future? Data location?
   h.   Model acceptable to Air Force?
   i.   Feasibility of being used by Air Force policy makers.
   j.   How is job performance measured?
   k.   What is the linkage between job performance and accession attributes?
   l.   Are there objective criteria to evaluate alternative policies?
   m.   How to validate model in order to demonstrate its applicability and reliability to Air Force decision makers.

      Are there other areas that should be investigated and/or included?
Yes _____ No _____ If yes, what are those areas?

_____

_____

_____

      Are you aware of any models or analytical techniques currently being used to set selection/classification standards?

_____

_____

_____

_____

In your opinion, what are the operational constraints and other factors (such as policy, technical, or practical issues) which must be considered when setting selection/classification standards?

_____

_____

_____

In your opinion, in order to evaluate candidate models what are the most meaningful criteria (e. g., cost per productive man-month, productive capacity of the force, and minimum accession quantity and quality levels) to consider?

_____

_____

_____

How would you prioritize these criteria?

_____

_____

_____

Do you have any ideas or recommendations concerning how the Air Force should go about linking job performance measurement and enlisted standards?

_____

_____

_____

_____

In general, do you believe there are any other aspects of this effort that we ought to be considering?

_____

_____

Any general comments to improve this effort?

_____

_____

4.   This questionnaire will be administered to personnel at the: Air Force Human Resources Laboratory (AFHRL) involved in job performance measurement research and the selection/classification process; Air Force Military Personnel Center (AFMPC) involved in the determination of job classification; Air Force Recruiting Service (AFRS) involved in the development and application of the Procurement Management Information System (PROMIS) and the Processing and Classification of Enlistees (PACE) system; Air Training Command (ATC) involved with the PROMIS, PACE, training and policy-making processes; Headquarters USAF, DCS/Personnel, Directorate of Personnel Plans, Policy Division (AF/DPXOA) involved in the accession, selection and classification policy and the Air Force job performance measurement program; and the Office of the Assistant Secretary of Defense, Force Management and Personnel (OASD/FM&P) involved in accession policy and job performance measurement.   Specific individuals to be contacted include the following:

a.	AFHRL -	Lt Col Dan Leighton, Dr. Manuel Pina, Mr. Larry Looper, Capt Mark Emerson, Lt Col Nick Ovalle, Capt Marty Pellum, Dr. Henk Ruck, Dr. Joe Weeks, Dr. Bill Alley, Lt Col Rodger Ballentine
b.	ATC-	Col Fraine Zeitler, Lt Col Ed Cecconi, Maj Bill Cummins
c.	AFMPC -	Lt Col D. W. Richmond, Jr.
d.	AFRS -	Lt Col Frank Terrell
e.	AF/DPXOA -	Lt Col Doug Gorman
f.	OASD/FM&P -	Lt Col D. A. Harris

Are there other offices and individuals that should be included?
Yes _____ No _____ If yes, what additional offices are recommended?

_____

_____

APPENDIX C: ANNOTATED BIBLIOGRAPHY

ANNOTATED BIBLIOGRAPHY

Alley, W. E. (1987). <u>Occupational learning difficulty</u>. Paper prepared for the Committee on the Performance of Military Personnel, Commission on Behavioral and Social Sciences and Education, National Research Council, Washington, D. C.

 The present Joint-Service Job Performance Measurement/ Enlistment Standards Project has included only a few out of the many military entrance level occupations. Until such time that sufficient data concerning the linkages between aptitude tests and job performance measures have been collected to cover all or most specialties, the author describes "a conceptual framework and data analysis approach" to extend the utilization of existing data to include additional specialties. The theory is taken from the Air Force Learning Difficulty Project. The concepts of job learning difficulty, benchmark learning difficulty scales, and average task difficulty per unit time spent (ATDPUTS) are presented to provide a way to compare specialties with regard to a common metric. The Air Force Learning Difficulty Project "can serve as a timely and cost-effective model for extending the results of this work to specialties that have not been included in the empirical field studies."

Allred, L. J. (1986). <u>Alternatives to the validity coefficient for reporting the test-criterion relationship</u>. Paper prepared for the Committee on the Performance of Military Personnel, Commission on Behavioral and Social Sciences and Education, National Research Council, Washington, D. C.

 This paper describes various methods for displaying detailed information about the relationship between test scores and job performance measures. Several sets of hypothetical data are used to illustrate methods ranging from a full plot of test and performance scores to grouping test scores into intervals and then displaying distributions of test scores within those intervals. Expectancy methods (chart, table, and plot), used in the evaluation of the prediction of two-level criteria (e. g., success versus failure), and frequency tables, used in determination of maximum correct classifications, are also presented. The author concludes by stating "these methods are easily extended to any test-criterion situation.

The final choice of display methods should depend upon both test user needs and level of psychometric expertise."

Armor, D. J. (1985, October). Linking job performance to enlistment standards: Continuous vs. pass-fail models. Paper presented to the Joint-Service Working Group.

In using models to link job performance with enlistment standards, this paper deals with the issue of using performance scores that are transformed into some type of categorical measure, such as a pass-fail dichotomy based on a minimum acceptable performance standard, versus a continuous score approach. The Rand enlistment standards model is used to illustrate the use of continuous scores and to compare results with the pass-fail or minimum standard approach. Preliminary comparisons using Army data show the continuous scoring approach gives results close to those using the pass-fail approach.

Armor, D. J. (1987, March). Job performance measurement and defense manpower management. In H. G. Baker & G. J. Laabs (Eds.), Proceedings of the Department of Defense/Educational Testing Service Conference on Job Performance Measurement Technologies. San Diego, CA: Navy Personnel Research and Development Center.

This report reflects comments made by the author as the keynote speaker during the opening ceremonies of the Job Performance Measurement Technologies Conference held in March, 1987, in San Diego, California. Serving as the Principal Deputy Assistant Secretary of Defense, Force Management and Personnel, Dr. Armor spoke of four policy areas where the application of job performance measurement can have major benefits for manpower management.

The first area deals with accession policy and enlistment standards; i. e., validating enlistment standard, which is the original goal of the Joint-Service Project. The second area, also a validation effort, focuses on the relationship between training time and unit proficiency, based on actual unit performance. Evidence of a strong relationship here would provide better justification to Congress for funding requirements for various training programs. The third area centers upon readiness and force mix decisions and the need to improve unit readiness assessment; i. e., "to move from ratings of resources to measures of actual individual and unit performance."

The fourth area involves the acquisition of weapon systems. In this case, the need is to evaluate human performance as well as machine performance in considering total weapon system performance. The potential payoffs for the Joint-Service Project include "improving manpower management practice, resolving policy disputes, and defending our programs to Congress."

Armor, D. J., Fernandez, R. L., Bers, K., & Schwarzbach, D. (1982). _Recruit aptitudes and Army job performance_ (R-2874-MRAL). Santa Monica, CA: Rand Corporation.

After incorrect scoring procedures for the Armed Services Vocational Aptitude Battery (ASVAB) between 1976 and 1980 were identified, this Rand study was initiated to investigate the relationship between recruit aptitudes and job performance in Army jobs. The key policy question was whether revised enlisted standards would provide for a cost-effective manpower force. To address this question, a cost-effective tradeoff model was developed and tested using data for Army Infantrymen. The model is built upon the concept of a qualified man-month, defined as the number of months contributed by individuals who complete training, remain in the Army, and can pass an on-the-job Skill Qualification Test. By considering various costs for recruiting, training, and maintaining personnel, the model is used to compare various ability mixes to determine the most cost-effective enlistment standard. Detailed formulas and sample computer output are provided.

Burtch, L. D., Lipscomb, M. S., & Wissman, D. J. (1982). _Aptitude requirements based on task difficulty: Methodology for evaluation_ (AFHRL-TP-81-34, AD-A110 568). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

The development and application of a technology designed for the evaluation of the difficulty of Air Force jobs in conjunction with the aptitude level required for the job are described. The technology developed makes use of computed variables and task factor data collected by the Air Force Occupational Measurement Center as well as benchmark difficulty data collected by contract personnel experts for the specialties under study. The application of this technology provides a unique method of determining and comparing the learning difficulty of Air Force tasks and jobs, both within and across career specialties. Analyses have indicated high interrater reliabilities for both supervisory and benchmark ratings. A _two-variable_

multiple regression equation was developed for each of the specialties studied. Relatively high correlations were obtained between the two ratings, indicating that independent raters tend to agree with supervisors. These equations resulted in estimates of average task difficulty per unit time (ATDPUT) values for each job in each specialty. The value of these estimates and implications for their use are discussed (authors' abstract).

Carpenter, M. A., & Monaco, S. J. (1987). Time to proficiency. Paper prepared for the Training Systems Division, Air Force Human Resources Laboratory, Brooks Air Force Base, Texas.

The Time to Proficiency (TTP) project has two major objectives: "(1) to determine the feasibility and validity of using supervisor estimates as measures of job performance and to estimate the extent to which mental aptitudes affect job performance; and (2) to develop and apply a prototype analytical model to evaluate how changing aptitude requirements based on job performance information would affect occupational capability; manpower, personnel and training (MPT) policies; MPT programs; and MPT costs." Using data collected from supervisors within one Air Force specialty (Avionics Communications Specialist), regression techniques were used to estimate the effects of aptitude on productivity, while controlling for experience. A prototype model was then developed by integrating the functional and logical relationships of four component submodels (production, attrition, cost, and distribution of aptitude). Application of the prototype model yielded an optimum level of aptitude which minimizes cost per unit of production. Results appear promising; however, further refinement and testing are recommended.

Cascio, W. F. (1987). Alternative uses of performance data in manpower management. Paper prepared for the Committee on the Performance of Military Personnel, Commission on Behavioral and Social Sciences and Education, National Research Council, Washington, D. C.

A variety of different models using job performance measures are presented in this paper including an annotated bibliography on manpower management and human resource planning. From the literature review, the author concludes that " many authors talk about the importance of the relationship between expected job performance and manpower forecasts, yet no one has offered any method of doing so, " and possible methods are then suggested.

Considerable attention is given to the alternative metrics of job performance and a conclusion that " a measure of competency or level of job mastery is essential. " Four different ways of expressing utility (the overall payoff associated with the use of a selection procedure) are discussed: dollars, percentage increases in output, expected reductions in the number of hires required to do a job, and the labor cost savings associated with the reduced hires.

Two methods are presented to relate job performance to enlistment standards: expectancy charts and break-even analysis. The author concludes that " the technology for relating performance data to enlistment standards does exist, although some variations and extensions of traditional methodology are necessary in the context of military jobs. "

Department of the Air Force (1985). Quality requirements for Air Force military enlisted personnel. Paper prepared for the Office of the Assistant Secretary of Defense, Force Management and Personnel, Washington, D. C.

The 1985 Omnibus Defense Authorization Act directs the Secretary of Defense to submit to the House and Senate Committees on Armed Services a report detailing the current quality of the enlisted force in each Service, the projected quality requirements for enlisted personnel in each Service over the next 5 years, the recruiting and retention levels necessary over the next 5 years to sustain those quality requirements in each Service, and any changes to current compensation policies necessary to sustain those quality requirements. This report provides the Air Force position on each of these areas (author's abstract).

Dickinson, T. L., Hedge, J. W., & Ballentine, R. D. (1987, March). Predictability of the ASVAB for the Air Force's job performance measurement system. In H. G. Baker & G. J. Laabs (Eds.), Proceedings of the Department of Defense/ Educational Testing Service Conference on Job Performance Measurement Technologies. San Diego, CA: Navy Personnel Research and Development Center.

The Air Force Human Resources Laboratory (AFHRL) is currently developing a measurement system for obtaining job performance data. This job performance measurement system (JPMS) will serve three interrelated purposes. First, the JPMS will provide operational managers of the Air Force's human resources

program with criteria to evaluate program effectiveness. Second, the JPMS will provide Air Force research scientists with performance measures to use in research & development (R&D) projects. Finally, the JPMS will provide measures for assessing the predictability of the Armed Services Vocational Aptitude Battery (ASVAB) for on-the-job performance. This paper examined the underlying structure of the JPMS, and the predictability of the ASVAB for the JPMS (authors' abstract).

Fernandez, R. L. (1985). Setting enlistment standards and matching recruits to jobs using job performance criteria (R-3067-MIL). Santa Monica, CA: Rand Corporation.

    This report describes the research efforts of a two-year study carried out by the Rand Corporation's Defense Manpower Research Center for the Office of the Secretary of Defense. The results build upon the earlier work of Armor et al. (1982) and focus on the feasibility of the Rand cost/performance tradeoff model for the setting of enlistment standards, and on job performance measures in matching recruits to military specialties.

    Considerable detail is presented in examining the relationship between individual entry characteristics and two measures of job performance -- attrition and the Army's Skill Qualification Test (SQT). These two performance measures are combined into one single measure, qualified man-months, which is the key concept of the Rand model. Results using four Army military occupational specialties (Infantryman, Multichannel Communications Equipment Operator, Tactical Wire Operations Specialist, and Medical Specialist) are presented and analyzed.

    Conclusions are that the model does serve as a viable tool for the setting of job standards, but concerns exist with the "proportionality assumption," the choice of test difficulty, and the setting of standards objectively.

Garcia, S. K., Ruck, H. W., & Weeks, J. (1985). Benchmark learning difficulty technology: Feasibility of operational implementation (AFHRL-TP-85-33, AD-A161 797). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

    In 1973, the Air Force Manpower and Personnel Center requested that the Air Force Human Resources Laboratory develop

an objective procedure for establishing the relative aptitude requirements for enlistee occupations. After 10 years of extensive research, the Laboratory developed a state-of-the-art technology for this purpose. The technology produces measures of occupational learning difficulty that can be used as a job-centered frame of reference for establishing aptitude requirements. These measures were used as an empirical basis for establishing aptitude requirements in the April 1982 revision of Air Force Regulation 39-1, Airman Classification Regulation. Further, occupational learning difficulty is applied within Air Force person-job match algorithms for determining enlistee job assignments. Because occupational learning difficulty will be used for these purposes in the future, it is important that the associated measurement procedure be transferred to an operational organization for routine implementation. To transfer the technology it was first necessary to investigate the feasibility of having Air Force personnel, as opposed to research personnel, collect benchmark ratings for use in deriving the learning difficulty measures. For this purpose, eight members of the Air Force Occupational Measurement Center (OMC) collected benchmark ratings for nine enlisted specialties that had been previously evaluated by research personnel. For each specialty, a measure of occupational learning difficulty was derived. Ratings produced by the OMC team were then compared to ratings collected by the research personnel to assess the reliability and validity. Results of the analyses indicated that the reliability and validity of the OMC ratings were equivalent to the reliability and validity of the ratings previously collected by the research personnel. Hence, this study supports the feasibility of having OMC personnel routinely collect benchmark ratings of learning difficulty (authors' abstract).

Gott, S. P., Lesgold, A., & Glaser, R. (1987, March). Implications of cognitive psychology for measuring job performance. In H. G. Baker & G. J. Laabs (Eds.), Proceedings of the Department of Defense/ Educational Testing Service Conference on Job Performance Measurement Technologies. San Diego, CA: Navy Personnel Research and Development Center.

In comparison to a well-developed technology for aptitude measurement and selection testing, the measurement of learned occupational proficiency is underdeveloped. The problem is especially severe for the Armed Services because of the many highly technical jobs involved and the short periods of enlistment in which both training and useful performance must take place. To increase

the effectiveness of both formal training and on-the-job learning, we need forms of assessment that provide clear indicators of the content and reliability of new knowledge. Since many of the military's jobs have a major cognitive component, the needed measurement methodology must be able to deal with cognitive skills. In this paper we assert that the measurement of job performance should be driven by modern cognitive theory that conceives of learning as the acquisition of structures of integrated conceptual and procedural knowledge. At various stages of the acquisition process, there exist different integrations of knowledge, different degrees of procedural skill, differences in rapid memory access, and differences in the mental representations of tasks to be performed. To be maximally useful, proficiencey measurement must be based upon the assessment of these knowledge structures, information processing procedures, and mental representations. Advancing expertise or possible impasses in the course of learning will be signaled by cognitive differences of these types.

We present a cognitive account of the components of skilled performance, discuss specific measurement procedures that have been employed in various domains including Air Force technical occupations, and illustrate the utility of the measures in a successful training study with Air Force electronics technicians (authors' abstract).

Green, B., & Shavelson, R. (1987, March). Distinguished panel discussion on issues in the joint-service JPM program. In H. G. Baker & G. J. Laabs (Eds.), Proceedings of the Department of Defense/Educational Testing Service Conference on Job Performance Measurement Technologies. San Diego, CA: Navy Personnel Research and Development Center.

This report documents the comments made by the authors during a "distinguished" panel discussion presented on the third and last day of the Job Performance Measurement Technologies Conference held in March, 1987, in San Diego, California. Both authors serve on the Committee on the Performance of Military Personnel, National Research Council of the National Academy of Sciences. The major criticism to date of the Joint-Service Project by the Committee has been the concentration on the "norm-referenced" approach to test development and scoring; criterion-referenced measures are recommended. After discussing the design of job performance measurements, the authors present various inter-

pretations of the meaning of "linking enlistment standards to job performance." Interpretations range from a "giant validity study" to a much "harder problem of comparing the worths of performances on various jobs." For the more difficult interpretations the project is at "the edge of current scientific methodology."

Greer, O. L., & Cascio, W. F. (1987). Is cost accounting the answer? Comparison of two behaviorally based methods for estimating the standard deviation of job performance in dollars with a cost-accounting-based approach. Journal of Applied Psychology, 72(4), 588-595.

Accurate estimation of the standard deviation of job performance in dollars (SD$_y$) can improve the precision of utility estimates of expected payoffs from personnel programs. The purpose of this study was to compare directly the estimates of SD$_y$ obtained using a cost-accounting-based estimate of SD$_y$, the Global Estimation Model, and the CREPID procedure. The study was conducted in a large, soft-drink bottling company. Each method for estimating SD$_y$ was applied to the job classification, *route salesman*, producing three independent estimates of SD$_y$. These estimates were tested for significant differences. Results indicated that the Global Estimation Model estimate and the cost-accounting-based estimate were not significantly different, whereas the estimate produced by the CREPID procedure was significantly smaller. Limitations of the cost-accounting-based estimate are identified and results are discussed in terms of their implications for the theory and practice of utility analysis in organizations (authors' abstract).

Harris, D. A. (1987, March). Job performance measurement and the joint-service project: An overview. In H. G. Baker & G. J. Laabs (Eds.), Proceedings of the Department of Defense/Educational Testing Service Conference on Job Performance Measurement Technologies. San Diego, CA: Navy Personnel Research and Development Center.

This report reflects comments made by the author during the opening ceremonies of the Job Performance Measurement Technologies Conference held in March, 1987, in San Diego, California. Serving as Project Officer for the Joint-Service Project, the author briefly describes the history of job performance measurement activities since the initiations provided by Congress in 1980. The overall management structure for the Joint-Service Project is

presented including the composition and basic responsibilities of the Manpower Accession Policy Steering Committee, the Joint-Service Job Performance Measurement Working Group, and the National Academy of Sciences Committee on the Performance of Military Personnel. The ultimate goal of the project is "to validate quality enlistment standards against actual job performance, instead of success in training." Furthermore, once the research establishes a definitive link between enlistment criteria and job performance, "we will then be able to determine accession quality requirements with greater precision than is now possible."

Hedge, J. W., & Teachout, M. S. (1986). Job performance measurement: A systematic program of research and development (AFHRL-TP-86-37, AD-A174 175). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

This paper describes the Air Force's strategy for developing, evaluating, and selecting a measurement methodology for use in validating selection systems and evaluating training programs across a wide range of job specialties. Background, current status, and future plans of the job performance measurement project are discussed in terms of alleviating the criterion problem that has defied solution by industrial psychologists for many years (authors' abstract).

Hendrix, W. H., Ward, J. H., Jr., Pina, M., Jr., & Haney, D. L. (1979). Pre-enlistment person-job match system (AFHRL-TR-79-29, AD-A078 427). Brooks AFB, TX: Occupation and Manpower Research Division, Air Force Human Resources Laboratory.

Research discussed in this report involved the development of a computer-based assignment system which became operational Air Force wide 1 November 1976. The Person-Job Match System was the computer algorithm which matched potential recruits with available jobs. This algorithm, when operationally implemented, became the assignment algorithm of the Air Force Advanced Personnel Data System's Procurement Management Information System (APDS-PROMIS). This report presents the assignment concept, methods of combining multiple objectives, the conceptual payoff equation, baseline performance data, and future directions anticipated (authors' abstract).

Kyllonen, P. C., & Christal, R. E. (1988). Cognitive modeling of learning abilities: A status report of LAMP (AFHRL-TP-87-66, AD-A190 671). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

This paper describes some of the research activities underway as part of the Air Force's Learning Abilities Measurement Program (LAMP). A major objective of this basic research project is to devise new models of the nature and organization of human abilities, with the long-term goal of applying these models to improve current personnel selection and classification systems. The activities of the project have been divided into two categories. The first category is concerned with identifying fundamental learning abilities by determining how learners differ in their abilities to think, remember, solve problems, and acquire knowledge and skills. From research already completed , a four-source framework has been established that assumes observed learner differences to be due to differences in processing speed; processing capacity; and the breadth, extent, and accessibility of conceptual knowledge and procedural skills. The second category of research activities is concerned with validating new models of learning abilities. To do this, a number of computerized intelligent tutoring systems have been built that serve as minicourses in technical areas such computer programming and troubleshooting electrical circuits. A major objective of this part of the program is to develop principles for producing indicators of student learning progress and achievement. These indicators will serve as the learning outcome measures against which newly developed learning abilities tests will be evaluated in future validation studies (authors' abstract).

Maginnis, E. B., Uchima, A., & Smith, C. E. (1975a). Establishing aptitude requirements for Air Force jobs: Historical review of aptitude levels and impact on the personnel system (AFHRL-TR-75-44 [I], AD-A023 250). Lackland AFB, TX: Occupational and Manpower Research Division, Air Force Human Resources Laboratory.

This report is the first in a series of three. It presents a review of the military service aptitude batteries, with some comparisons of minimum aptitude scores required for entry to military occupational areas. Changes in Air Force aptitude score minimums are traced and summarized. A systems analysis of estimated impacts of different aptitude levels for enlistment on elements of the personnel system

leads to a statement of salient negative influences on promotion, performance, and job/service satisfaction (authors' abstract).

Maginnis, E. B., Uchima, A., & Smith, C. E. (1975b). Establishing aptitude requirements for Air Force jobs: Some personnel system actions to offset negative impacts of aptitude changes (AFHRL-TR-75-44 [II], AD-A022 206). Lackland AFB, TX: Occupational and Manpower Research Division, Air Force Human Resources Laboratory.

If aptitude level for entry to an occupational specialty is set at higher or lower than optimal, there can be negative impacts on certain elements of the personnel system. This report considers personnel system actions that might offset these negative effects. Some relationships between system actions and Air Force needs are presented first. Then personnel system actions with potential value are identified and judged for their impact on system elements. Finally, the actions so identified are evaluated for potential effectiveness in offsetting negative impacts under conditions of lower, and then higher, aptitude than the optimal. Some relative estimates of cost of system actions are given as examples of an approach to selecting actions for implementation. Of the five alternative actions evaluated, the most preferred was one that provides the greatest opportunity for exposure to a maximum of jobs within a specialty (authors' abstract).

Maginnis, E. B., Uchima, A., & Smith, C. E. (1975c). Establishing aptitude requirements for Air Force jobs: Methodological approaches (AFHRL-TR-75-44 [III], AD-A022 250). Lackland AFB, TX: Occupational and Manpower Research Division, Air Force Human Resources Laboratory.

This report presents, using a system-oriented approach, alternative methodologies that could be used to establish aptitude requirements for Air Force occupations. It covers a description of the aptitude requirements system, a review of the interaction of aptitude requirements and personnel system actions, and a functional flow for the requirements system. A flow for the developmental activities necessary to design and implement the system is also given, followed by recommendations for development of a methodology for determining aptitude requirements for effective job performance, with separate consideration for optimal aptitude types and levels with respect to career development, assignment flexibility, and job satisfaction (authors' abstract).

May, L. J. (1986). _Educational quality requirements for Marine Corps enlisted personnel_ (CNR 121). Alexandria, VA: Center for Naval Analyses.

> This report sets forth a methodology for determining the optimal mix of Marine Corps enlisted personnel. Assuming a goal of maximizing net benefit, high school graduates and nongraduates were evaluated in terms of both cost and performance differences. High school graduates cost more to recruit than nongraduates but have a lower attrition rate. In addition, there is abundant evidence that high school graduates perform better than nongraduates on the job. Educational requirements for new accessions were determined for several cost and relative-performance scenarios (author's abstract).

May, L. J. (1987). _Alternative modeling approaches for setting cost-effective qualification standards_ (CRM 87-54). Alexandria, VA: Center for Naval Analyses.

> The Rand Corporation has developed a model that determines cost-effective enlistment standards for military occupational specialties. Since this model may have an impact on enlistment policy, it is important that the modeling approach used to determine the enlistment standards be fully understood. This research memorandum describes the modeling technique used by the Rand Corporation and compares the Rand approach to alternative modeling methods in an attempt to determine the sensitivity of the model outcome to the methodology employed (author's abstract).

May, L. J., & Mayberry, P. W. (1986). _The Rand cost-performance model for setting qualification standards: preliminary comments_ (CRM 86-200). Alexandria, VA: Center for Naval Analyses.

> The Rand Corporation has developed a model to determine cost-effective qualification standards for military occupational specialties. Since this model may potentially have an impact on enlistment policy, it is important to fully understand its assumptions and procedures. This research memorandum examines key elements of the model, discusses the impact they have on the outcome of the model, and identifies issues that might benefit from further analysis (authors' abstract).

Mayberry, P. W. (1986). From hands-on measurement to job performance: The issue of generalizability (CRM 86-214). Alexandria, VA: Center for Naval Analyses.

The generalization from hands-on test scores to performance in a military occupational specialty can be threatened by many potential sources of error within the measurement process. Such sources of error can include scoring inconsistencies by test administrators, testing over a long period, and diverse test content. This analysis estimates the influence of these factors on the hands-on scores for three Marine Corps specialties. Estimates of test reliability are discussed in light of the effect of the measurement factors on the hands-on scores. Research designs to assess specific issues of reliability are proposed for the full-scale administration of hands-on tests to the Infantry occupational field (author's abstract).

Mumford, M. D., Weeks, J. L.., Harding, F. D., & Fleishman, E. A. (1987). Measuring occupational difficulty: A construct validation against training criteria. Journal of Applied Psychology. 72(4), 578-587.

Burtch, Lipscomb, and Wissman's (1982) occupational learning difficulty index attempts to measure the difficulty of occupations by aggregating workers' evaluations of task learning time. In the present study we examined the construct validity of this job analysis index. To accomplish this, 48 different occupational training programs were described in terms of 15 training content variables, 6 student characteristics variables, and 7 training performance variables. The results, obtained in a correlational analysis, indicated that the occupational learning difficulty index yielded an interpretable pattern of relationships with the training content and performance variables. We conclude that this task learning time index displays some construct validity as a measure of occupational difficulty and, therefore, should prove of value in designing training, manpower allocation, and job evaluation systems (authors' abstract).

National Academy of Sciences (1987). Summary report: Competency measurement subgroup meeting, October 24-25, 1986 and March 13-14, 1987. (Unpublished Manuscript.)

This report documents the discussions between the National Academy of Sciences (NAS) Committee on the Performance of Military Personnel and the Joint-Service Job Performance Measurement (JPM) Working Group concerning the NAS

Committee's recommendation to focus job performance measurement research on the development of competency-based measures. That is , the research design should focus on having an absolute scale of performance, with scores referenced not to the relative scores of others but to levels of job mastery. Rationale for the recommendation is presented along with other proposed uses of job performance measures.

Nord, R. , & White, L. (1987). The measurement and application of performance utility: Some key issues. Paper prepared for the Committee on the Performance of Military Personnel, Commission on Behavioral and Social Sciences and Education, National Research Council, Washington, D. C.

A primary concern of this paper, and of the research it describes, is with the complex relationship between the value of a soldier's performance in a job and the value of a distribution of soldier performance within and across jobs. In particular, we examine the issue of how " performance value" in a job changes as a function of changes in the distribution. The importance of this variation depends on several things, including (a) the nature of the alternatives being evaluated; (b) the degree to which individual performance is likely to be similar in different jobs (the dimensionality of performance); and (c) the magnitude of the differences in distributions that can result by choosing different policies.

The questions addressed in the paper are exclusively applicable to measurement of performance value in a context where conventional economic theory may appear inapplicable. However, the paradigms embedded in micro-economic production theory provide a convenient and useful framework within which the assumptions embodied in alternative measurement approaches can be examined. Within this framework, soldier performance in a given job can be treated as a "factor" or input to a hierarchical production process, and the "value" of performance is defined in terms of its immediate contribution to job output and indirectly through the contribution of the job to the Army's mission(s) (authors' introduction) .

Office of the Assistant Secretary of Defense, Manpower, Installations, and Logistics (1984). Joint-service efforts to link enlistment standards to job performance. Third annual report to the House Committee on Appropriations. U. S. Department of Defense, Washington, D. C.

See OASD (1986).

Office of the Assistant Secretary of Defense, Force Management and
Personnel (1985). Joint-service efforts to link enlistment standards
to job performance. Fourth annual report to the House Committee on
Appropriations. U. S. Department of Defense, Washington, D. C.

See OASD (1986).

Office of the Assistant Secretary of Defense, Force Management and
Personnel (1986). Joint-service efforts to link enlistment standards
to job performance. Fifth annual report to the House Committee on
Appropriations. U. S. Department of Defense, Washington, D. C.

This report, which is submitted annually to the House and
Senate Committees on Armed Services and Appropriations, sum-
marizes the history of the Joint-Service Job Performance Measure-
ment/Enlistment Standards Project. The authors (OASD, 1986: ii-iii)
provide the following overview:

This fifth annual report builds on the first four, which
focused on the strategy, structure, and implementation of the
DoD effort. The first report (December 1982) outlined the
actions taken to establish formal Office of the Secretary of
Defense oversight of the Joint-Service Project. The second
report (December 1983) described the Joint-Service research
strategy for developing job performance measures and testing
the feasibility of linking enlistment standards to job perform-
ance data. The third and fourth reports (December 1984 and
1985) described the Services' progress in implementing the
overall research strategy. This report: 1) highlights the
significant issues, events, and accomplishments during calendar
year (CY) 1986; 2) reviews the Service-by-Service progress in
developing and implementing job performance measures; and
3) outlines the National Academy of Sciences Committee on the
Performance of Military Personnel's recommendations and
evaluation of the Joint-Service Project.

Specifically, the contents of this report are as follows:
Chapter One summarizes the Project's history and working
relationships with oversight groups. Chapter Two outlines the
Project's research and development strategy. Chapter Three
describes significant events and accomplishments of the Joint-

Service effort during CY 1986. Chapter Four contains the National Academy of Sciences' recommendations for the Joint-Service Project. Chapters Five through Eight report individual Service progress.

Schmitz, E. J. (1987). Improving personnel performance through assignment policy. Paper prepared for the Committee on the Performance of Military Personnel, Commission on Behavioral and Social Sciences and Education, National Research Council, Washington, D. C.

The U S Army Research Institute (ARI) has developed the Enlisted Personnel Allocation System (EPAS) to recommend training assignments to new recruits. This system, based upon a combination of optimization and decision rules, can increase soldier performance substantially over the present assignment system. Results of EPAS simulations are compared with the present system, increased enlistment standards, and improvement of the job composite tests. Finally, economic and psychological models are used to assess the value of these performance increases to the Army (author's abstract).

Sellman, W. S. (1987, March). Response to panel discussion on issues in the implementation of a job performance measurement program. In H. G. Baker & G. J. Laabs (Eds.), Proceedings of the Department of Defense/Educational Testing Service Conference on Job Performance Measurement Technologies. San Diego, CA: Navy Personnel Research and Development Center.

On the last day of the Job Performance Measurement Technologies Conference held in March, 1987, in San Diego, California, a panel discussion was held to address various issues in the implementation of a job performance measurement program. The panel was composed of five members of the Joint-Service Job Performance Measurement Working Group. This report summarizes three observations made by Dr. Sellman as Director of Accession Policy, .Office of the Assistant Secretary of Defense, Force Manpower and Planning. The first observation concerned the panel's discussion of the Army Skill Qualification Test (SQT) program. Dr. Sellman points out one important event not mentioned by the panel was the impact of the ASVAB misnorming on the SQT program. The second observation emphasized Dr. Sellman's philosophy against the concept of "if it ain't broke, don't fix it." The third observation provided clarification that the purpose of the Job Performance Measurement Project is "not to

validate ASVAB against job performance. The purpose is to validate enlistment standards against job performance."

Strickland, W. (1987, March). Panel discussion on issues in the implementation of a job performance measurement program. In H. G. Baker & G. J. Laabs (Eds.), <u>Proceedings of the Department of Defense/Educational Testing Service Conference on Job Performance Measurement Technologies</u>. San Diego, CA: Navy Personnel Research and Development Center.

On the last day of the Job Performance Measurement Technologies Conference held in March, 1987, in San Diego, California, a panel discussion was held to address various issues in the implementation of a job performance measurement program. The panel was composed of five members of the Joint-Service Job Performance Measurement Working Group. This report contains the comments made by the author as a panel member representing the Accession and Reenlistment Policy office at the Air Staff level. One area the author focuses attention on is, beyond validation of ASVAB, what research products will be implemented?

Ward, J. H., Jr. (1977). <u>Creating mathematical models of judgment processes: From policy-capturing to policy specifying</u> (AFHRL-TR-77-47, AD-A048 983). Brooks AFB TX: Occupation and Manpower Research Division, Air Force Human Resources Laboratory.

Planning for a computer-based personnel job opportunities system for the Air Force led to a requirement for a procedure to generate a "payoff" or "value" of the assignment of each person to each possible job. This report discusses three methods of weighting different information to form a single indicator of "payoff" or "value," explicit weighting and two implicit weighting methods -- policy-capturing and policy-specifying. The two implicit weighting methods are combined into a more comprehensive method referred to as policy-development.

The policy-capturing process presents a series of decision situations to one (or more) policy makers and the policy maker assigns to each situation a number which reflects the "value" or "payoff." Then a mathematical model is derived by obtaining the regression equation that best predicts the policy maker's judgments.

Policy-specifying, which is the main focus in this report, does not depend on a sample of actual judgments to determine the regression weights, but attempts to translate into mathematical form a policy maker's more global statements about the general properties that the model should have. The mixing of policy-capturing and policy-specifying leads to a process called policy-development (author's abstract).

Waters, B. K., Laurence, J. H., & Camara, W. J. (1987). Personnel enlistment and classification procedures in the U. S. Military. Paper prepared for the Committee on the Performance of Military Personnel, Commission on Behavioral and Social Sciences and Education, National Research Council, Washington, D. C.

This paper begins its analyses of the selection and classification processes within the military by first examining the topics in a more general setting outside the military. Section II discusses the conceptual basis for selection decisions with regard to setting standards, establishing cut scores on selection tests, and validating the selection procedures. It ends with a comparison of the similarities and differences between the military and civilian environments. Sections III and IV describe the military's selection and classification systems, respectively. Section V focuses on the processes used by the Military Services to set and revise their selection and classification standards: how the standards evolved, how they are changed, and the rationale for changes. Key accession and recruiting policy officials were interviewed to determine who recommends and who makes the decisions of Service enlistment selection and classification standards and upon what bases the decisions are made. Finally, the information gathered and reported is used in Section VI to develop a model of military selection and classification processes. Examples from the Military Services are described. The paper ends with a brief discussion of conclusions from the study (author's introduction).

Weeks, J. (1984). Occupational learning difficulty: A standard for determining the order of aptitude requirement minimums (AFHRL-SR-84-26, AD-A147 410). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

Entry into Air Force enlisted job specialties is largely governed by aptitude requirements. Specification of aptitude requirements involves two separate decisions: an aptitude type (i. e., the Mechanical, Electronics, General, or Administrative aptitude index of

the Armed Services Vocational Aptitude Battery) is identified; then, a minimum level of aptitude (i. e., a percentile score cutoff) is determined. Although identification of the appropriate aptitude type is relatively straightforward, determination of the aptitude minimum is complicated by several considerations. The problem which served as the basis of this research was the need for a quantitative method for determining percentile score cutoffs.

A method for determining aptitude minimums based on occupational survey information is described. For job specialties having a common aptitude requirement type, measures of occupational learning difficulty are proposed as a frame of reference for determining the order of aptitude minimums. Rather than representing how difficult tasks are to perform, a measure of occupational leaning difficulty for a given specialty represents how much time it takes to learn to perform associated tasks. It is recommended that percentile score cutoffs be established so that the order of the cutoffs corresponds to the order of specialties in terms of occupational learning difficulty. Assuming high-aptitude enlistees learn faster than low-aptitude enlistees, the recommended procedure will ensure that job specialties which require the most time to learn are manned by enlistees who learn the fastest.

To produce measures of occupational learning difficulty, comprehensive occupational analyses were conducted for more than 200 job specialties and over 10,000 job types. Comparisons of the order of aptitude mimimums (i. e., percentile score cutoffs) with the order of specialties in terms of learning difficulty indicate that aptitude minimums for some specialties are seriously misaligned. Some specialties high in learning difficulty have low minimums, and other specialties low in learning difficulty have high minimums. Such misalignments suggest that the talent available to the Air Force is not being allocated in the most optimal manner (author's abstract).

Wigdor, A. K., & Green, B. F., Jr., (Eds.). (1986). Assessing the performance of enlisted personnel. Washington, D. C.: National Academy Press.

The Committee on the Performance of Military Personnel, formed within the National Academy of Sciences in late 1982, is composed of nationally recognized experts in scientific and technical areas related to the Joint-Service Job Performance Measurement/ Enlistment Standards Project. The Committee's purpose is to provide independent technical review of the Joint-Service Project research

activities. This comprehensive report (121 pages) documents a recent assessment of the Project.

The report is organized into two sections. The first section focuses on work accomplished to date and the second section on upcoming issues in analyzing the data collected with the newly developed criterion measures. The project is "in the process of transforming the pivotal issue in criterion research from that of demonstrating the validity of a particular measure to the more complex task of comparing the substantive and psychometric adequacy of alternative criterion measures."

Wise, L. L., Campbell, J. P., & Arabian, J. M. (1987). The Army synthetic validation project. Paper prepared for the Committee on the Performance of Military Personnel, Commission on Behavioral and Social Sciences and Education, National Research Council, Washington, D.C.

This project is designed " to identify and evaluate alternative procedures for validating potential selection composites when a full empirical validation is simply not feasible. The project also will examine procedures for establishing performance standards for each job and using these standards to set minimum qualifying scores on new selection composites." This report describes the synthetic validation approach including critical assumptions and details of the project plan.